Fire Management on the Public Lands

Department of the Interior
au of Land Management

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DESCRIPTION OF THE PROPOSAL

PURPOSE AND SCOPE

The Bureau of Land Management (BLM) is responsible for the management and protection of 446 million acres (U.S. Department of the Interior, 1976) of public lands in the 13 Western States and Alaska. In this capacity it is responsible for the fire management program which includes: (1) taking all action necessary to prevent and suppress destructive fires and (2) integrating the use of fire as a complementary tool in reaching resource management objectives.

Although fire often has been viewed as a negative and destructive force, increasing recognition is being given to fire's role as an environmental factor contributing to ecosystem diversity over evolutionary periods of time. Thus, the complex question facing land managers is how to combine an understanding and application of the role of fire in ecosystems development with the demonstrated need of society for natural resources and for the protection of investments. Agee (1974) stated that as population grows and the level of developments and social values increase, the proportion of human-caused or natural fire increase. This damage can easily run into millions of dollars per year. But a fire program consisting solely of fire suppression has major disadvantages in wildland ecosystems that are often under consideration. Although fire suppression will always be necessary to protect developed areas, cultural improvements, and our investments in natural resources for the production of goods and services, its application to entire ecosystems can result in unnatural ecosystems changes and constantly increasing probabilities of catastrophic fires (Agee, 1974).

Also, absolute fire suppression begins to reach a point of diminishing returns. An increasing fire control technology means increasing expenditures to sustain the technology, resulting in temporary "control" of fire on the landscape. But as fuel hazards increase on contiguous acres over time, the probabilities of large, high-intensity fires increase. An increasingly sophisticated and more costly technology is then required to handle larger and more devastating fires--and so the trend continues.

The answer to the land manager's fire dilemma lies in an integrated fire management program that reduces losses, complements natural resource management objectives, and sustains the productivity of biological systems.

Most Bureau management programs affecting the environment are the resource program activities of forestry, range, wildlife, watershed, recreation, minerals, and rights-of-way. The fire management program is an important service or support activity having definite effects upon the individual resources and the environments in which they are managed. It is considered an insurance program, protecting management's objectives and investments in its various resources activities.

This proposal highlights the changes from fire control to fire management. Fire management concerns itself not only with fire prevention, suppression, and rehabilitation but with the actual management of this environmental force. This includes not only the suppression of wildfires, but also prescribed (controlled) fire and in some areas, such as in wilderness, allowing naturally caused fires to burn under specific conditions.

The proposal consists of four integrated fire management activities:

- Presuppression and prevention--includes detection, planning hazard reduction, prevention information and education, and investigation and enforcement;

- Suppression--all of the activities associated with the control and extinguishment of a fire;

- Postsuppression--all of the activities associated with rehabilitating resources and facilities destroyed or damaged by fire or the suppression action;

- Prescribed fire--the use of fire to accomplish specific land management objectives under certain controlled conditions and approved coordinated plans. Prescribed fire can include ignitions by natural causes if other prescribed conditions are satisfied.

The purpose of this staff report is to evaluate the impacts the Bureau's fire management program will have upon the usefulness, productivity, and ecosystem of the public lands managed by the Bureau.

Since the fire management program has various impacts on the environment it was originally decided to publish a programmatic environmental impact statement on the Bureau's current fire management program. This was to have been prepared in compliance with Section 102(2) (c) of the National Environmental Policy Act (NEPA) of 1969. Bureau policy also requires an analysis to be made for every BLM action which may affect the quality of the environment. Subsequent determinations were made that, generally, programmatic EIS's do not meet NEPA requirements for site specific impacts and quantitative analysis. As a result, the original EIS has been changed to this report.

Since this staff report covers fire management activities on 446 million acres, it treats in general all the environmental impacts from such activities. More detailed environmental assessments may be necessary for specific fire management plans at the local management levels, such as States, districts, and/or other geographic areas.

The objectives of the fire management EIS are to:

- Provide a general description of the fire management program, its implementing activities, and an evaluation of its overall environmental impacts;

- Serve as the basis for any subsequent environmental reviews or analysis that may be required for specific fire management actions on a geographical or project basis.

The proposed program action presented in this report includes all fire management activities practiced by the BLM for the purpose of protecting human life and property and for enhancing the environment and productive capacity of public lands in meeting resource production goals and other human needs.

This proposal emphasizes the management of fire from the viewpoint of the four major component activities of presuppression and prevention, suppression, postsuppression, and prescribed fire.

These are not four clear-cut activities; rather, in a fire management program they are focused into one comprehensive action to protect, manage and obtain best use of our natural environment.

Many of the fire management practices are being carried out on most of the public lands. Some of the practices are not in effect because of technical, economic, or environmental constraints. In changing concepts from fire control to that of fire management two significant areas require special attention; (1) integrated use of natural and social sciences and environmental designs arts, and (2) increased use of the interdisciplinary approach.

The statement is limited to actions on public lands in the following States; Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, North Dakota, South Dakota, Oregon, Utah, Washington, and Wyoming.

BACKGROUND AND HISTORY

Fire has been one of the greatest gifts of mankind. It allowed migration from warmer to colder climates. It provided warmth, artificial light, and the opportunity to cook food. It transformed man from an individual into an integral part of a community and helped him learn

cooperation in a permanent home with organized family life. Mankind came to depend more and more on fire as a device to fabricate the things needed to support life and comfort.

Migrants to Alaska from Asia were already familiar with fire. These early Alaskans knew that certain animals were attracted by new burns (Slaughter, et al, 1971). Indians at times set fires to drive game to convenient kill sites and they also used fires in fighting enemies.

Early settlers in the eastern U.S. considered the forest as an obstacle to their use of the land. Except for the Great Plains, almost the entire area needed for agricultural settlement had to be hewn from a seemingly never ending forest. Fire was the principle force available to the settlers for freeing the land from forest growth (Brown and Davis, 1973). During Western settlement, many people were careless with fire or burned the mountains on purpose to make easier access for prospecting.

Though large forest fires occurred before the coming of the white man, their size, intensity, and frequency were greatly increased by settlement, mining, and logging. Concepts about forest and forest fires naturally developed: the forest's inexhaustibility; the sooner the potential agricultural land was cleared the better; forest fires, except as they threatened personal property or specific stands, did not cause important damage (Brown and Davis, 1973).

The history of organized fire management can be divided into three periods: prior to 1910, from 1910 to 1933, and after 1933. The first period marks the growth and application of protection on the national forests where large-scale organized fire control began and much technical development has been centered. The second period saw the protection of privately owned forest land, initially undertaken by the large owners themselves, but later assumed in large degree by State protection services.

The passage of the Taylor Grazing Act in 1934 set the stage for the third period, the protection and management of unreserved public domain located in the Western States and the Territory of Alaska. Although this Act did not itself affect Alaska, it was followed in 1939 by the Alaska Fire Control Act. In 1946, the Alaska Fire Control Service, the Grazing Service, the General Land Office, and the Oregon and California Land Administration, all with responsibilities for this vast acreage, were combined and became the Bureau of Land Management with full protection responsibilities.

FIRE PROBLEM

The Bureau of Land Management is responsible for managing and protecting 446 million acres of public land from wildfire. Through cooperative agreements and contracts with other agencies, both Federal and non-Federal, the Bureau also has an important role in protecting other acreage under their ownership. This other acreage varies in size annually depending upon contracts.

There is a definite upward trend in fire occurrence and this trend directly affects the scope and costs of the fire management program. Throughout the public lands, there is an increasing demand for recreational access, and former wildlands are being utilized for both residential and commercial purposes. Not only does the increasing population increase the risk of fire but also fires are occurring in areas formerly relatively free from occurrence.

Table I-1 indicates fire occurrence on all lands protected by BLM force account or contract programs, and provides data on acreage lost and offers 5-year and 10-year running averages to indicate trends. Table I-2 indicates relative resource values lost on the public lands.

Changing resource values and required increases in management intensity also mean that even if fire occurrence had not increased, the standards of protection would have to be tightened. Wildfire becomes intolerable when resource values and risk are both high.

For example, in some areas today, the very high values placed on watershed and urban developments of metropolitan areas or the "fronts" behind cities such as Boise and Salt Lake City make fires nearly intolerable and intensive fire control measures are taken. This causes sharp increases in suppression costs.

PROGRAM PLANNING AND DIRECTION

The multiple demands placed upon public land and resources by a public with wide-ranging interests make the determination of "public interest" a complex process.

DECISION-MAKING PROCESS

In 1964, BLM started developing a planning process to better determine which land use, or combination of land uses, should take place on an area. After a period of design and testing, the BLM planning system was adopted and implementation started in July, 1969. This system is presently used to develop and maintain land-use plans that consider all the various resource uses for all public lands.

The BLM planning system is similar to traditional planning approaches. It includes such usual components as goals, objectives, inventory of physical resources, socioeconomic data, and public participation. However, it differs in several ways. It has techniques requiring the description and comparison of "trade-offs," and what is gained or lost when decisions are made to accept various alternatives. Another major departure from traditional planning philosophy is the concept and requirement of assessing the single-use potentials of each physical resource.

In brief, the system works as follows: The first step in the procedure is to delineate the BLM-administered land into geographical areas called "planning units." These units serve as the basis for collection and analysis of basic resource inventory data. In some cases, the planning units are combined into planning areas for purposes of preparing the management framework plan (MFP). Under the BLM system the MFP is the land-use plan. A unit resource analysis (URA) is prepared for each planning unit. The URA includes a detailed description of the existing environment of the planning unit, a physical inventory of individual resources (lands, minerals, livestock forage, forestry, recreation, wildlife, watershed), and an analysis of the resource production opportunities without multiple-use consideration.

After URA's are completed, an MFP is prepared for a planning area. This area may cover one or more planning units. Basically, the MFP is the result of a process designed to identify and reconcile major land- and resource-use conflicts. The MFP provides a set of goals, objectives, and constraints for a specific planning area to guide the development of detailed plans for the management of each resource. It is prepared using an interdisciplinary approach at the field level by BLM employees. Coordination with a variety of groups and interests is obtained in an organized public participation process.

The MFP for a specific planning area describes the various resource uses that are premissible after considering BLM policy guidance, the facts about the resources and uses, view of the public, and other inputs to the decision-making process. In addition, the MFP describes the constraints on planning necessary to ensure compatibility of uses, protection and enhancement of the environment, and other management objectives.

The MFP process requires three steps. Step 1 is the development of a set of recommendations showing the optimum use and/or development for each resource, constrained only by the resource capability, the limiting effects of policy, and social and economic data as provided by other components of the planning system. Step 1 also includes environmental enhancement and protection recommendations. Step 2 covers conflict

resolution and development of alternatives to solve or minimize the conflicts. This step makes alternative multiple-use recommendations for the planning area, thereby resource-use conflicts are resolved and constraints are established to guide management of each resource. The final step involves the decision-maker's selection of a set of alternatives to guide future programs. The decision-maker is guided by policy and public views. Public involvement in developing MFP occurs at all steps, beginning with URA.

FIRE PLANNING SYSTEM

The BLM fire planning system is a part of the total Bureau planning system and has input into both the URA and MFP.

The fire management input to the URA consists of a description of the fuels, values at risk, fire behavior, and fire occurrence. These characteristics are combined to provide an evaluation of the fire problem in the planning. An interdisciplinary resource team approach is used in determining these characteristics and the products are included in the URA step 2, physical profile.

By incorporating the fire problem with a statistical calculation of the normal fire year and normal fire year weather, a normal fire year model is developed. Numerous tactical inputs can be changed to achieve various management alternatives for organization. This input into the MFP will allow management to select the alternatives to best achieve MFP land-use objectives.

Following approval of MFP and subject to available funds and manpower, program activity plans are prepared for each activity, to lay out in detail how each activity will achieve the objectives and meet constraints shown in the MFP. The program activity plan for fire management is the Normal Fire Year Plan (NFYP) (U.S. Department of the Interior, 1978). The BLM planning system represents the process by which many of the mitigative measures described in part IV are prescribed for use in any particular area.

See appendix L for further discussion of the fire planning system.

AUTHORITY AND POLICY DIRECTIVES

BLM's authority to administer the fire management program on public lands is as follows:

- Protection Act of September 20, 1922 (42 Stat. 857; 16 U.S.C. 594);

- Economy Act of June 30, 1932 (47 Stat. 417; 31 U.S.C. 686);

- Taylor Grazing Act of June 28, 1934 (48 Stat. 1269; 43 U.S.C. 315);

- Oregon and California Act of August 28, 1937 (50 Stat. 875; 43 U.S.C. 1181e);

- Reciprocal Fire Protection Act of May 27, 1955 (69 Stat. 66; 42 U.S.C. 1856 and 1856a);

- Public Land Administration Act of July 14, 1960 (74 Stat. 506; 43 U.S.C. 1361);

- Disaster Relief Act of May 22, 1974 (88 Stat. 143; 42 U.S.C. 5121);

- Alaska Native Claims Settlement Act of December 18, 1971 (85 Stat. 688; 43 U.S.C. 1601);

- Federal Land Policy and Management Act of October 21, 1976 (90 Stat. 2743; 43 U.S.C. 1701);

Policy directives (contained in appendix A) for the fire management program can be found in the following:

- Departmental Manual, Part 910 DM 1, Wildland Fire Control and Management, Release No. 2097, dated June 12, 1978;

- Departmental Manual, Parts 296 DMI, 910 DM 2, Fire Protection and Assistance, Release No. 2116, dated September 25, 1978;

- BLM Manual 1603.12I, Fire Protection Program Activity Policy Statement, Release No. 1-835, February 12, 1973;

- BLM Manual 9210, Fire Management, BLM Manual 9210.06.

FIRE MANAGEMENT INTERRELATIONSHIPS WITH OTHER AGENCIES

There are various levels of coordination, cooperation, and interrelationship in existence among the BLM and other Federal, State, municipal, and private agencies.

Following are the various types of fire management interrelationships at the various levels that are in existence:

- Interior Fire Coordination Committee-- the Interior Fire Coordination Committee operates under the direction of the Assistant Secretary--Land and Water Resources--for the U.S. Department of the Interior. It provides leadership and advice for the development, coordination and maintenance of superior wildland fire presuppression and suppression capabilities, and the standardization of procedures, methods, and practices within the Department of Interior.

- Suppression actions-- the Bureau of Land Management is directed to arrange for the expeditious dispatching of available firefighting support when requested to assist in fire emergencies on other agencies' lands.

-Cooperative agreements--where the heads of the BLM consider formal cooperation necessary and desirable, agreements are encouraged with other Federal, State, or local government agencies and with privately organized agencies or associations. In addition to the formal cooperation outlined, informal cooperation brought about by sound public relations in the vicinity of national resource lands under the Bureau's jurisdiction is important and necessary.

- Emergency assistance--according to the Reciprocal Fire Protection Act of May 27,1955, emergency assistance in the absence of a formal cooperative agreement may be provided to properties immediately adjacent to national resource lands under the Bureau's jurisdiction where fire facilities are maintained.

According to the Disaster Relief Act of May 22, 1974, the BLM may provide emergency assistance to any State or local government for suppression of fire officially declared as threatening destruction amounting to a major disaster.

- Research--under the Protection Act of May 22, 1928, as amended, the Secretary of Agriculture is authorized and directed to conduct investigations and experiments for the purpose of determining the best methods of protecting timber and other forest growth from fire and other harmful agents. The BLM identifies subjects needing further research or development and requests the Forest Service to conduct appropriate studies or development at various experiment stations and equipment development centers.

DESCRIPTION OF THE PROPOSED FIRE MANAGEMENT PROGRAM

This proposal shifts the emphasis of BLM's protection program from fire control only to that of integrated fire management on 446 million acres of public lands in the Western United States and Alaska. This is in accord with similar shift of emphasis by the Department of the Interior on November 1, 1974. The program benefits and requirements are briefly discussed below.

The program will (1) help BLM to better achieve, retain, or enhance its resource management objectives; (2) relate most fire management practices to environmental and economic considerations; (3) assure minimal or acceptable adverse environmental impacts due to fire; (4) attempt where beneficial and practicable to restore in whole or in part former natural ecosystem development through use of fire; and (5) relate the fire management restoration effort to the values at risk.

The proposed program requirements in terms of funding, manpower, equipment, and facilities will not be significantly different from the present program level and the approved 1970 Normal Fire Year Plan with 1972 and 1978 updates. A detailed breakdown of the organizational plan, cost estimates, and fire load may be obtained by reviewing the BLM's Normal Fire Year Plan. It may be obtained at the Department of the Interior, BLM, Division of Fire and Aviation Management, Washington, D.C. The fire management program is funded through regular appropriated funds for the presuppression-prevention activity, and emergency appropriated funds for the emergency presuppression-prevention, suppression, and postsuppression activities. The prescribed fire activity involves both regular and emergency appropriations. Hazard reduction would be funded from regular and/or emergency presuppression appropriations; prescribed fires to achieve resource management objectives would be financed from regularly appropriated resource management funds. The fire manager develops a program on the basis of need, but the program that is implemented is based on the manpower, funds, and other resources that are approved in the operating budget.

The proposed Fire Management Program consists of an organization of 280 permanent and 2,013 temporary personnel. Within this 14-State area are various fire management locations utilizing 346 ground tankers, 50 contract aircraft, and other related facilities, equipment, and supplies. The Normal Fire Year Plan has been updated in 1978 to reflect environmental, economic, management, technological and similar changes. Table I-3 summarizes the NFYP update.

Suppression costs of the proposal will be no greater and, in fact, will be less in some prescribed fire areas. Prescription fires to fulfill resource management objectives may cost less than conventional methods presently being used. Prescribed fire shall be selected only when it will be the most suitable alternative to other methods of achieving resource management objectives.

FIRE MANAGEMENT ACTIVITIES

This program is divided into four activities: presuppression and prevention, suppression, postsuppression, and prescribed fire.

Presuppression and Prevention

This activity is accomplished in advance of fire occurrence to assure more effective fire suppression and to reduce the number of man-caused fires. The activity includes various types and levels of planning; procurement and maintenance of equipment and supplies; fire hazard reduction; education; investigation and enforcement; and the creation, maintenance, and improvement of firebreaks/fuelbreaks.

Prevention. A wildfire prevented does not have to be suppressed and does no damage. Fire prevention can be accomplished either by removing the fuel that could ignite or by removing the ignition source. Fire prevention plans are prepared at the area level, and consolidated at the district and State levels. These plans are updated annually and accomplishment reports are submitted annually.

The direct prevention of fires through hazard reduction means removal of fuels exposed to sources of high risk. This is well illustrated by the cleared and burned railroad right-of-way and by the developed campground where all dead fuels have been removed. Refer to appendix B for a detailed discussion of classification of hazard-reduction practices.

Beyond the concept of mere prevention of ignition is the expanded theory of preventing or limiting the spread of fire following ignition or preventing the rapid buildup of heat energy. In a practical sense, the objectives becomes prevention of large or uncontrollable fires (conflagrations) rather than simply a reduction in the total number of fires (Brown and Davis, 1973).

A firebreak/fuelbreak is a natural or constructed barrier utilized to stop or check fires or to provide a control line from which to work. It is distinguished from the fireline by being constructed in anticipation of future fires. Firelines are constructed during the suppression action on a going fire.

Methods of constructing and maintaining firebreaks/fuelbreaks may be classified as mechanical, chemical, vegetative, biological, and burning. They may be employed singly or in a combination.

- Mechnical--most firebreaks/fuelbreaks are constructed by mechnical means employing common land clearing equipment, usually power operated. Where topography and cover permit, fire plows are commonly used. (Brown and Davis, 1973).

- Chemical--herbicides for both herbaceous and woody plants are extensively used in right-of-way maintenance by railroads, highway departments, power companies, and on firebreaks/fuelbreaks as well. Chemicals employed to keep firebreaks/fuelbreaks free of flammable vegetation are of two general types: (1) the inorganic poisons which kill all vegetation and sterilize the soil for a certain period and (2) organic compounds, usually of hormone derivation, which are more selective in their lethal effects and more temporary since they oxidize without leaving any poisonous residue in the soil. (Brown and Davis, 1973).

- Vegetative--lush ground vegetation is an excellent fuelbreak cover as long as it remains green (Brown and Davis, 1973).

- Biological--sheep and goats are used to maintain breaks in some areas.

- Burning--the burning of protective strips is a common practice. Farmers, railroad companies, highway departments, and others frequently burn out roadsides and rights-of-way to remove fuel accumulations and to encourage growth of green vegetation (Brown and Davis, 1973). Refer to appendix D for fuelbreak considerations.

The purpose of area fuel reduction treatment is to reduce fuel hazards over a given area to facilitate control. Area treatments can achieve several objectives either singly or in combination by:

- Slash Disposal--fire hazard on an area increases greatly following timber cutting primarily because a large volume of the finer and potentially flammable fuels from the tree crowns called "slash" lose most of their moisture and are concentrated on the ground surface. Refer to appendix D for a more detailed discussion on slash disposal considerations.

-Broadcast burning of natural fuels--broadcast burning of forest and rangelands, called "light burning," has been and is being done for a number of purposes and is a common practice in certain areas. The purposes intended usually are to reduce fuel hazards, to improve pasture conditions, to improve hunting and increase game populations, to reduce harmful insect and other populations, and to improve general visibility and accessibility for the user.

A good information and education program is one of the keys to an effective fire prevention program and to an effective fire management program. The basic principles of this program are gaining attention and recognition through repetition, continuity, and accuracy. To inform the public of the prevention program, all communication techniques available must be utilized, such as campaigns, television, radio, newspapers, signs and posters, personal contact, and fire prevention awards. Communication techniques must also be utilized in order to explain and promote the entire fire management program, especially the use of prescribed fire.

Investigation of all wildland fires is done as soon as possible after detection to determine cause and possible trespass occurrence. In determining fire origin, burning pattern indicators are used. Intensive analysis of the origin is necessary to determine what prevention and/or enforcement action should be taken.

The enforcement of fire laws, regulations, and trespass is a key prevention measure.

Presuppression. The BLM Normal Fire Year Plan was prepared and this plan with revisions determined the fire management program level necessary to meet protection standards in a normal fire year. The Normal Fire Year Plan development was previously discussed under Fire Planning and is fully described in appendix L.

One of the presuppression requirements preparatory to fire suppression is the planning and development of a preattack program. The objectives of preattack planning are to anticipate and take actions that will enable Bureau personnel to make effective initial attack on fire. The functional requirements of fire management are considered before planning total preparedness efforts with the primary functional requirements of fire management being safety, organization and management, communication, fire weather, training, detection, dispatching, facilities and vehicles, supplies, and equipment.

Despite fire prevention programs, wildfires do occur and the promptness of their detection is the key to early suppression.

An organized detection program has two objectives: (1) discover and report every wildfire in time to control it at a small size with available initial attack forces and (2) locate the fire accurately so forces can immediately be dispatched by the most direct route.

Aerial detection provides more uniform, more flexible, but less continuous coverage. A stationary lookout provides limited area observation, but more continuous coverage. Although emphasis may be placed upon a particular detection source(s), provisions are made for all other possible alternate sources. The detection program in BLM is carried out by all detection methods in various combinations and quantities.

Refer to appendix C for a more detailed discussion of detection.

Suppression

This activity is concerned with fire extinguishment. It starts with the discovery of a wildfire and continues until the fire is out.

It includes the practice of fireline construction with power equipment (plows, bulldozers, trenchers, and pumpers), handtools, and fire retardant chemicals; burning out and backfiring; establishing and operating fire camps; and the management of men, equipment, and aircraft.

Each wildfire that breaks out has certain unique characteristics. Its behavior varies according to fuels, topography, weather, and other factors of the environment. Consequently, no two fire suppression jobs are exactly alike and how to control a fire cannot be specifically detailed in advance. All firefighting follows certain basic principles and is carried out using methods developed through experience and research.

Fireline Construction. The aim of all fire suppression is to either remove the fuels, reduce the temperature of the fuels or exclude oxygen which reflects the scientific principle that fire cannot occur without fuel, heat, or oxygen. The most common method used is the removal of fuels by creating a fireline void of fuels around the fire. A fireline is constructed by using power equipment, hand tools, or fire retardant chemicals.

Fire retardant chemicals as a way of inhibiting combustion or of retarding or extinguishing a fire or portion of a fire have been used since the 1950's. The types of chemicals used are wetting agents, viscous agents, and flame-inhibiting chemicals. These retardants are delivered by ground tankers and applied or aerially applied with aircraft. All three types of retardants are used by BLM. See glossary for agent and chemical descriptions.

Either burnout or backfire must be used to remove any unburned fuel between the fireline and the fire. The success or failure of all indirect methods of fire attack depends on this removal. The purpose of burning out or backfiring is to create an effective fuelbreak between a wildfire and unburned fuels.

Human Presence. The fire suppression effort brings people, equipment, and aircraft into the fire area, and the resultant impact upon the local environment will depend upon the size and location of the fire to be suppressed.

The size, location, and number of fire camps will depend on fire size and required control time. These can vary from a single two-man camp to many camps containing several thousand men, associated equipment, and supplies. Special provisions are necessary for feeding, sleeping, and provisioning crews.

The size, location, type, and quantity of various fire-suppression equipment will vary according to fire size and location.

The use of aircraft in the fire suppression program for various support and tactical assignments is typical of fire activities today. Aircraft are classified by type and use and include helicopters as well as fixed-wing.

Fire crews are used to build firelines to contain and control the fire, to burn out or backfire, and to mop up the fire.

Refer to appendix E for a more detailed discussion of fire equipment and aircraft used in suppression practices.

Postsuppression

The postsuppression activities are those fire rehabilitation actions that are promptly initiated and/or implemented following the disturbance or destruction of vegetative cover by wildfire or suppression practices to minimize: (1) loss of soil and onsite productivity; (2) loss of water control and deterioration of water quality; and (3) damage to life and property onsite and offsite in the most economic manner possible to the extent practical.

To describe the postsuppression program, its objectives, practices, and techniques, two categories of rehabilitation must be considered: rehabilitation of fire suppression damage and rehabilitation of burned areas.

Suppression Damage. To be effective, all vegetation along a fireline is removed (with the exception of line constructed with fire retardant), exposing the mineral soil to the erosive action of wind and water. This portion of the postsuppression program involves the rehabilition of firelines as part of the final mopup operation to prevent erosion, stream damage, flooding, etc.

Before a fire suppression operation is demobilized a fireline rehabilitation plan is developed and implemented. The amount of fireline to be rehabilitated and the methods used depend on such factors as steepness of slope, exposure, permafrost, soil moisture, soil type, and vegetative type.

In additition to rehabilitation of firelines, maintenance or other corrective measures may be necessary at the fire campsite(s), heliports, or on roads leading to and from the fire that may have been damaged by vehicles used during fire suppression. Damage from these activities are usually minor except in Alaska permafrost areas where damage by vehicles can by extensive if proper procedures are not followed.

Burned Areas. Bureau policy provides that the rehabilitation of wildfire burns and the replacement of facilities destroyed by fire is an emergency program and only the protection of life, fire suppression, and protection of property have a higher priority.

Detailed examination of burned areas to determine damage and rehabilitation needs begins as soon as suppression activities permit. An interdisciplinary approach is used, whether by one resource manager in the case of small fires where resource damages are minimal or by a team of resource management experts in the case of large fires where more manpower and expertise is needed to identify damage and rehabilitation needs. A fire rehabilitation plan (see appendix F) is prepared. The plan includes the identification of resource damage, rehabilitation needs and justification, an analysis of the environmental impacts of the proposed treatments and alternative treatments, and a request for the necessary emergency funding to complete the job. The complexity of the plan needed to rehabilitate a particular burn depends on many factors such as intensity of burn, watershed and wildlife values damaged, soil type, and climate.

The two broad categories of practices in a rehabilitation plan include (1) protection and management practices and (2) treatment practices. Protection and management are always given first consideration in the rehabilitation of a burned area. This is often the most effective and least costly treatment and may be all that is needed to ensure recovery.

Exclusion of domestic livestock from the burn is often the most critical and important element of proper rehabilitation. Length of deferment will be based on the physiology of key plant species including the extent of damage to the plants. As a minimum, the area will be closed to grazing for at least one growing season following the burn. Two seasons' deferment is the perferred practice.

Protective fencing and water developments are planned to meet not only the emergency protective needs but also long-term management objectives. The burned area may be closed to wildlife and people so they do not interfere with the restoration of the burned area.

It may be necessary in certain areas to restrict all or some resource uses to reduce deterioration and aid in recovery of the burned area.

Treatment practices are selected to prevent erosion, sediment and flood damages, impairment of water quality, invasion of noxious or undesirable vegetation, replacement of fences and other facilities necessary for rehabilitation work, and to assure timely recovery of forage, wildlife habitat, and timber resources to normal productivity. Refer to appendix F for a more detailed discussion of postsuppression or fire rehabilitation practices.

Prescribed Fires

This activity is the controlled application of fire to wildland fuels to achieve certain planned objectives. It includes the use of fire in forest management, grazing, fire hazard reduction, disease or insect control, etc.

Prescribed fires are a tool of management. They are confined to specfic areas, regulated in intensity, and otherwise controlled to achieve the desired objectives. They are based on sound knowledge of fire effects and behavior as related to weather, fuel, topography, smoke emission, and other factors.

When managers decide to use prescribed fire or burning to achieve their objectives, the area must be specifically designated and the entire detailed procedure defined on a project basis. This plan (appendix G), when administratively approved, must then be forwarded to appropriate State and local air quality offices for review and approval of the project. Details must also be worked out for actual project implementation dependent on current and forecasted weather conditions.

Specifications for selecting the necessary weather conditions to accomplish required smoke dispersal from smoke-sensitive areas without exceeding ambient air quality standards are covered by the general smoke management plan previously agreed upon by cognizant State air quality control agencies and resource management agencies. (See appendix H for sample smoke management plan.) Provisions of the smoke management plan must also be followed for fires not intentionally ignited but permitted to burn by reason of conformance with plans for prescribed fires.

Prescribed fire is a specific as well as a natural tool of management. In the hands of professionals it may be used by managers to achieve, among other things:

- Thinning of forest stands;
- Removal of competing weed species;
- Better seedbed for desirable species;
- Control of certain types of disease or insects that breed in slash, dense ground cover, etc.;
- Perpetuation of fire-dependant ecosystems in natural/wilderness areas;
- Maintenance of specific fire climax types;
- Reduction of slash and accumulations of hazardous material adversely affecting fire operations;
- Maintenance of fuelbreaks for fire control purposes and protection of stands;
- Either vegetative type conversion or maintenance for the benefit of wildlife;
- Control of disease hosts adversely affecting wildlife;
- Type maintenance or conversion of grasses to benefit both game and domestic stock;
- An increase in water yield on some areas and in others to increase water retention in the watershed;
- Cleaner areas of forest and range for use of tourists and recreationists.

All these and other benefits can accrue in the wise use of prescribed fire. The use of prescribed fire in hazard reduction has been discussed previously under Presuppression and Prevention.

The above-listed uses of prescribed fire are well documented in <u>Fire and Ecosystems</u> (Kozlowski and Ahlgren, 1974), <u>Forest Fire Control and Use</u> (Brown and Davis, 1973), and <u>Annual Proceedings</u>, 1961-1974, Tall Timbers Fire Ecology Conference.

Past Program and Proposal Differences

Continued in the fire management proposal is the strong fire prevention, detection, and initial attack capability of the past fire control program. However, subsequent suppression action--as to kind, intensity, and urgency--will be directly related to the values at risk, the least expenditure of funds for effective suppression, and methods of suppression least damaging to resources and the environment. The relationship of values to least damaging methods and least expenditure of funds as a protection objective is a change from the "minimum burned acreage" criteria.

Additionally, the expanded use of prescribed fire and the recognition of natural fire in a fire-dependent ecosystem are program differences. Prescribed fire is the controlled application of fire, regardless of ignition source, to wildland fuels to achieve specific planned management objectives. The quantity, kind, and extent of prescribed fires are entirely up to the manager's ability to perform them.

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PART II

DESCRIPTION OF THE ENVIRONMENT

For the purpose of this statement, five major biomes have been identified which cover the 446 million acres of public lands that may be affected by the proposal. Figures II-1 and II-2 show the location of the public lands. Five biomes involved in this EIS include, (1) grassland, (2) desert, (3) woodland-bushland, (4) coniferous forest, and (5) tundra.

Biomes are major living (biotic) communities, or natural groups of organisms, characterized by certain "dominant" plants and animals (Odum, 1945). They include both aquatic and terrestrial communities and also contain biotic "islands" more characteristic of other biomes. The islands are caused by geographical, climatic, altitudinal, and other variations with in a particular biome.

Figures II-3 and II-4 indicate the boundaries between the biomes. However, the biomes are really separated by transitional zones or ecotones, where the elements of adjacent biomes blend. Appendices I, J, and K detail soil stability, classification, and characteristics by major biome.

THE ROLE OF FIRE IN THE ENVIRONMENT

Although the effects of fires on wildland ecosystems have been well documented (Lutz, 1956: Daubenmire and Daubenmire, 1968), fire has traditionally been viewed as a negative or destructive force. Although man is well acquainted with the harmful aspects of fire, now he is gaining a much fuller appreciation of the natural role of fire in many ecosystems. As a result of the recent interest in fire's role in the environment, revised concepts and new approaches are emerging for fire control and fire use.

Fire is a process in the biomes. Flammability is an interaction between plant communities and other environmental components. Practically every dry season a significant fire is possible in many grassland, ponderosa pine forests, and savanna woodlands, because these communities bring certain properties to the ecosystem that enhance flammability. Under natural conditions, characterized by rather frequent fires, these communities would generally experience lower intensity fires, thus, their composition and structure are maintained by periodic fires because inherent characteristics ensure repeated fires. These communities are fire dependent.

One hypothesis even suggests such fire-dependent plant communities burn more readily than non-fire-dependent communities because natural

Figure II-1 Major Concentrations of Public Lands Administered by the Bureau of Land Management

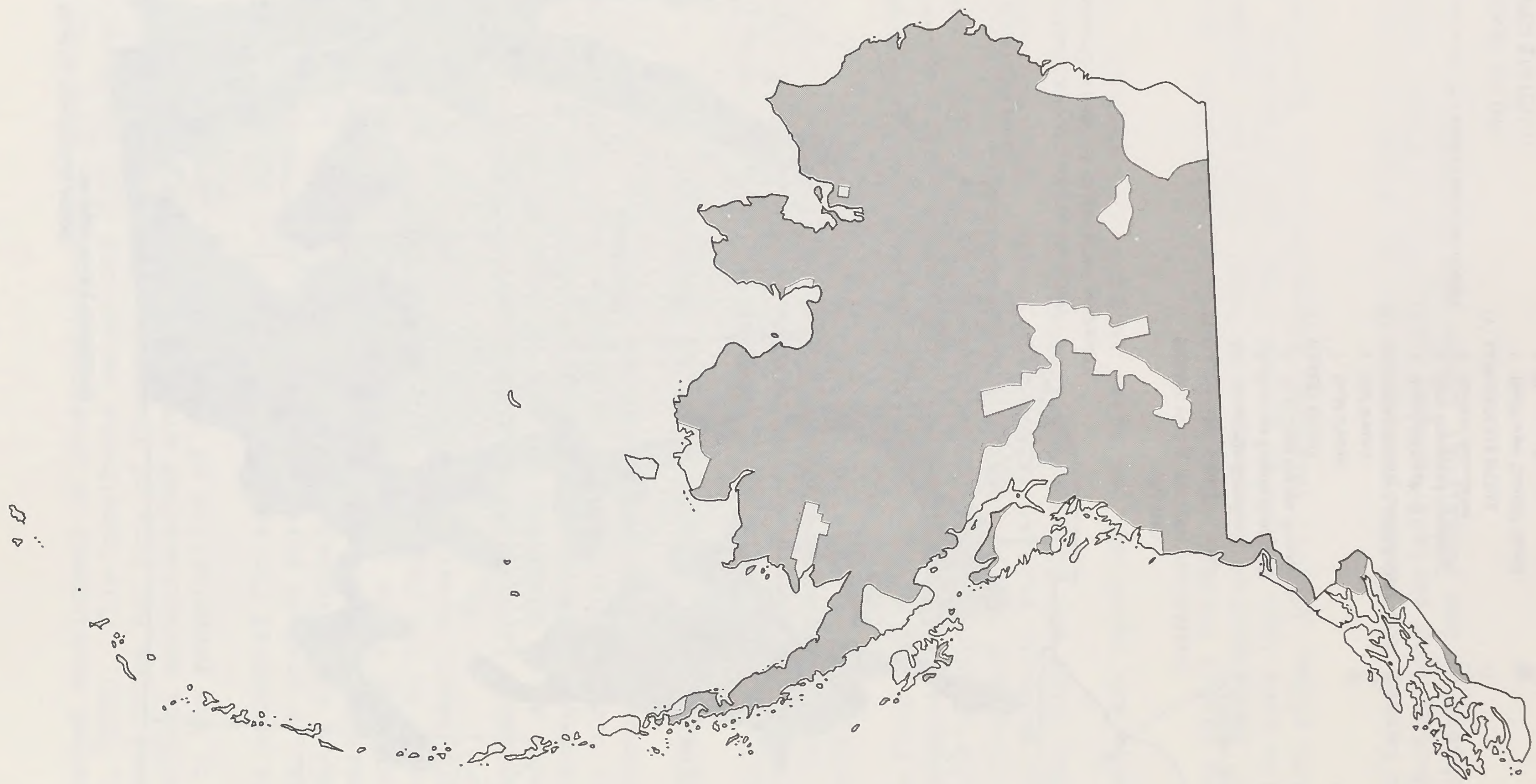
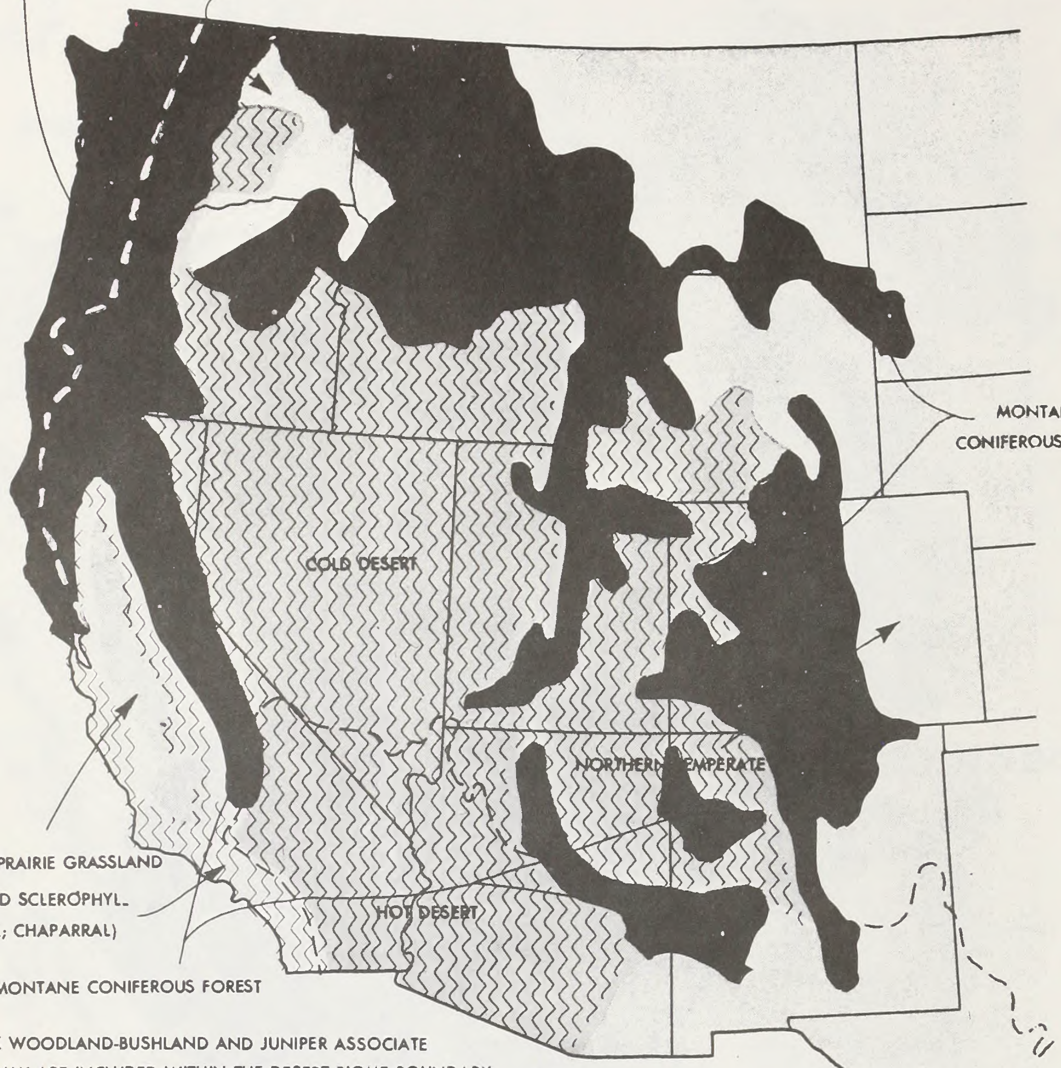


Figure II-2. Major Concentrations of Public
Lands in Alaska



THE OAK WOODLAND-BUSHLAND AND JUNIPER ASSOCIATE GENERALLY ARE INCLUDED WITHIN THE DESERT BIOME BOUNDARY.

LEGEND

BIOMES IN THE WESTERN UNITED STATES

I. GRASSLAND BIOME
   1 Temperate Grassland
   2 Palouse Prairie Grassland
   3 California Prairie Grassland

II. DESERT BIOME
   1 Cold Desert
   2 Hot Desert

III. WOODLAND-BUSHLAND BIOME
   1 Broad Scleraphyll
   2 Oak Woodland-Bushland*
   3 Juniper Associates*

IV. CONIFEROUS BIOME
   1 Northwest Caostal Farest
   2 Montane Farest

(*Generolly included within the desert biome baundary.)

FIGURE II-3 BIOMES OF THE WESTERN UNITED STATES (1)

selection has favored development of characteristics that make them more flammable (Mutch, 1970). This hypothesis recognizes that plant species which have survived fires for tens of thousands of years may not only have selected survival mechanisms but also inherent flammable properties that contribute to the perpetuation of fire-dependent communities.

However, the potential for spreading fires is not present in all plant communities. A gradual physical deterioration is often the factor that finally induces high flammability in lodge-pole pine, spruce, and northslope communities in the coniferous biome. This deterioration leads to high intensity fires that cause stand replacement within these forest communities. So the impact of fire within a biome varies tremendously with the frequency, duration, and intensity of burn.

For these reasons, it is misleading to generalize about fire. Fire can still be viewed as an ecosystem process in terms of general principles. Wright and Heinselman (1973) listed factors, processes, and effects common to the coniferous biome. This listing is repeated here because these general principles are common to many other biomes as well:

FIRE AS AN INFLUENCE ON THE PHYSICAL CHEMICAL ENVIRONMENT

Fires directly release the mineral elements as ash from the living and dead organic substances burned. The burned system components may include organic layers, litter, foliage, bark, wood, fruits, seeds, animals and their excrement, etc.

Indirectly, fires may release still more mineral elements through (1) increased decomposition rates of remaining organic layers and other remains, (2) leaching or erosion of mineral soils, and (3) splintering of rocks, and the subsequent breakdown of rock fragments, etc. The quantities of minerals released are poorly known. They are certainly significant if the fires are intense and frequent.

Some nutrients are vaporized, at least in part, for example, nitrogen compounds.

Fire reduces plants thereby increasing surface temperature resulting in increased soil temperatures and changes in local climatic regimes. The effect varies with burn type (crown or ground fire) and intensity. The effect varies with slope, aspect, latitude, elevation, soil moisture, soil properties, etc.

In Northern Canada and Alaska permafrost may be thawed following fires, or conversely, during long periods between fires, the activate layer may decrease in thickness or new permafrost layers may originate.

Fire As a Regulator of Dry-Matter Accumulation

Fires directly recycle the carbon of herbs and shrubs, and the foliage, bark, and wood of trees. Conversely, without fire, as the stand matures and decomposition fails to keep pace, these components gradually accumulate. The proportion of the dry matter consumed varies with fire type, intensity, and frequency. These in turn vary with many environmental factors.

In litter and humus layers, fires may consume the carbon and sometimes remove increments of peat. Conversely, in the absence of fire these layers increase to the extent that decomposition fails to balance accumulation. The imbalance is related to site factors including temperatures, precipitation, evaporation, latitude, elevation, and topography.

Following severe fires the killed trees (snags) may consitute a large reservoir of dead organic matter.

Fires may retard the accumulation of humus and peat for a period after burns through effects of soil nutrients, temperatures, and permafrost. The effect is complex because of interactions with the evapotranspiration balance and the groundwater levels on the sites where accumulation is more rapid.

Fire As a Controller of Plant Species and Communities

Fire may trigger the release of seeds as well as stimulate the flowering and fruiting of many shrubs and herbs.

Fires alter seedbeds. If litter and humus removal are substantial, large areas of bare soil, thin ash, or thin humus may be created. These influence germination and survival of many plants. Among trees benefiting from such seedbeds are most northern pines, Douglas fir, giant sequoia, some species of spruce, and many others.

When the taller plants are killed, vegetative reproduction of many plant species is stimulated. These plants sprout from the root collar (birch, maples, oak, redwood, hazel, alders willows, etc.) or root suckers (aspens).

Competition for moisture, nutrients, heat, and light may be eliminated or temporarily reduced by fires. The effect may selectively favor some stand strata or components, or be total depending on type of fire and intensity.

Fires may selectively eliminate part of a plant community by consuming only the surface vegetation or only the treetops.

Frequency of fire (return interval) influences community composition and successional stage, and controls overstory age for vegetation and types reproduced by crown fires (jack pine, lodge-pole pine, black spruce, etc.).

Fire frequency regulates susceptibility of forests to the destruction of trees by wind (blowdown).

Fire As the Determinant of Wildlife Habitat Patterns, Populations

Fire increases foods for animals (elk, deer, moose, beaver, hare, porcupine, etc.) that depend on forage or browse plants that proliferate after a fire. Yields of many berry-producing shrubs that serve as food sources for birds, rodents, and bears are increased.

Fire eliminates (for 50-100 years) some plants characteristic of old forests--notably tree lichens and ground lichens in the north. It removes lichen used by barren-ground caribou on winter ranges, and by woodland caribou farther south.

Many insect populations, some of which are important food sources for warblers, woodpeckers, etc., are regulated. There may be increases or decreases in food availability, depending on prey and predator.

The scale of the total vegetation pattern through fire size, intensity, and frequency (the natural fire rotation) is controlled, and the relative abundance of plant communities and successional stages is influenced. These determine habitat patterns for all herbivores and, therefore, regulate their numbers to the extent that populations are habit limited. Carnivores (wolf, cougar, coyote, fisher, mink, marten, lynx, eagles, hawks, etc.) depend on herbivores and, therefore, on the fire-created vegetative pattern.

Fire As a Controller of Forest Insects, Parasites, Fungi, etc.

Fire directly terminates outbreaks of the spruce budworm, mountainpine beetle, and other insects, by eliminating their hosts over sizable areas. Fire or the lack of it regulates the total vegetive pattern and the age structure of individual plants within it. These influence insect

populations. Insect outbreaks may create fuel concentrations that make large scale fire possible. Such fires then terminate the outbreak until the stands again attain susceptible ages. A self-perpetuating interaction may occur.

Fires temporarily eliminate such plant parasites as mistletoe on black spruce, lodge-pole pine, and perhaps other species. It may also "sanitize" forests against other pathogens for a time.

In summary, the flammability of wildland fuels and the effects of fires on the biomes are regulated by variations in plant succession and fuel succession. Simply stated, the cyclic occurrence of fires regulates plant communities and plant communities regulate the character of fires.

The ecology of the five biomes is generally a disturbance ecology, and fire has been the frequent initiator of such disturbances, often sustaining the productivity of many ecosystems.

Climate in Relation to Wildlife Severity

Weather is the controlling factor in determining the timing, duration, and even existence of wildfires. Every biome or BLM administrative area experiences severe weather conditions conducive to the support of conflagration wildfires. These, like any specific weather situation, occur more or less randomly perhaps several times in the average year, but varying from no occurrences to many. Any area with a history of large fires has experienced these situations.

Although the weather influence is highly variable in any given period of time, in an average year a portion or portions of the year can be identified as usually being sufficiently dry and windy to indicate probable need for fire suppression action (table II-1). Such portions of the year define the fire season. Not all fire weather is limited to this normal fire season--unusual periods of dry and windy weather have produced wildfire problems for several months on either side of the usual fire season in most BLM districts.

Most BLM wildfires are caused by lightning and all BLM districts are subject to fire-starting lightning storms, some for more than 30 days in an average fire season. Lightning storms vary greatly in frequency from year to year and in intensity of lightning output from storm to storm. An individual lightning storm may set over

100 fires in a few hours in an area 15 miles wide and 150 miles long. Characteristically, days with weather situations that produce a single intense storm are also likely to produce multiple storms. Every few years an outbreak of severe lightning storms occurs in combination with prolonged extremely dry and windy weather. When it does, fire suppression forces of all agencies are taxed far beyond the normal demands made upon them. These are the kinds of weather situations that account for the greatest fire suppression costs and damages.

Air Quality As Affected by Fire

Portions of the atmosphere become relatively stationary for varying periods of time. During such periods any gaseous or fine particulate emission tend to accumulate near their sources usually in the lower layers of air. This condition routinely exists during calm night and early morning hours when smoke from smoldering fires is transported by downslope and downvalley breezes into nearby lower basins where it accumulates and, during certain weather situations, may persist for several days.

During windy conditions smoke from fires may stay close to the surface, covering whatever areas may be directly downwind. In contrast, if light winds are near the surface, fires tend to form tall convecture columns of rising warm air that lift the smoke to considerably higher elevations where it is transported and dispersed by the winds with minor affect on the quality of surface air. The hotter, larger fires produce higher convective columns, and the smoke plume that drifts away from such a column may be distinguishable for great distances.

Frequently, higher layers of the atmosphere are warmer than the relatively cool air "pools" near the surface. Air pollution problems may result when these stagnant pools are located in areas of high-pollution sources. Such areas of limited air circulation are located in all the biomes. Many people in such areas are very sensitive about pollution sources that may add additional air impurities.

Smoke from wildland fires and prescribed burning may be emitted into layers of air that do not come in contact with earth's surface. Such smoke contributes to the general pollution of the troposphere from west to east across the United States is a common sight to air travelers. Lovelock (1971) estimates that the pollution of air masses in the heavily populated and industrialized north temperate zone is increasing 30 per cent per decade. This general increase is noted locally as a gradual increase in background measurements. Though smoke from large wildfires contributes noticeably from time to time, over the last 50 years, wildfires acreage has definitely decreased in all forest areas (Cramer, 1974).

Composition of smoke from wildfires varies with the specific fuel and intensity of the fire, but in general is considered to consist of 11-58 pounds of particulate, 4-20 pounds of hydorcarbons, 40-140 pounds of CO, 1,600-2,500 pounds of CO2 and about 1,000 pounds of water vapor for every ton of forest fuel consumed (Hall, 1972). Though smoke from wildfires can be worked up into impressive totals of emission components, these bear little relation to air pollution because little of the smoke reaches the areas where air pollution is of real concern. If it does, it is usually for the short duration and at low concentration.

Although the smoke produced by any fire largely depends on the composition of the fuel, smoke production characteristics can be divided into startup, full-fire, and die-down periods. During the startup period, a much larger proportion of products will be emitted directly without burning. The fire will be generally cool and the combustion inefficient. In heavy fuels, this stage is the shortest.

In the full-fire or mature stage, the fire, for its particular fuels, moisture, and arrangement, burns at maximum temperature and rate. Most emission will be less because combustion is most complete and rate of energy production greatest.

In the final stages, the temperature is lower, flaming gives way to glowing combustion, and remaining fuels may produce a higher proportion of CO and a greater amount of unburned distillation products and particulates. This stage is probably the most troublesome because most of the heat energy is gone, the emissions may accumulate or drift at fire elevation, and this stage in scattered heavy fuels may last longer than the other two.

Size of fire is also important in determining relative efficiency of the combustion process primarily by influencing temperature. Laboratory tests indicate minimum production of particulate, total hydrocarbon, and CO irrespective of type of wood waste or moisture content while temperature in the combustion zone remained 1,100°F (593°C) (Prakash and Murray, 1972). Fuel elements in close proximity are heated by radiation from adjacent fuel elements. Fuels near the edge of the fire are heated less by both radiation and conduction and are likely to burn cooler. Edge fuels are also subject to reduction of temperatures by conduction from cool air outside the fire. Thus, the less the edge effect the higher the average temperature of the fire and the more complete the combustion. The smaller the fire the greater the proportion near its periphery and the less complete the combustion.

GRASSLAND BIOME

The grassland biome is the most extensive and varied of the biomes. This biome consists of five subregions. The four shown on figure II-5 contain significant areas of public land. The subregions are:

- The northern temperate grasslands extends from the eastern forest across the Mississippi Valley to the foothills of the Rockies and includes the Great Plains.

- The southern temperate grassland includes southwest Texas and southern New Mexico.

- The Palouse prairie includes small portions of eastern Washington, northern Idaho, and northeastern Oregon.

- The California prairie includes the Central Valley of California.

- The Coastal prairie (not shown on figure II-5) includes the area along the Gulf of Mexico in south Texas and parts of southern Louisiana. It will not be discussed, as it contains no significant amount of public land.

The general aspect of the four subregions to be discussed is shown in figures II-6 through II-9.

Topography

The topography of the northern temperate and southern temperate grasslands is predominantly rolling hills and plains. The land in the northern and southern temperate grasslands generally slopes gently from west to east, with altitudes ranging from 4,000 to 5,000 feet along the western boundary and 400 to 500 feet along the eastern boundary. There are several isolated mountain groups in the western edge of the region--the Black Hills in South Dakota and the Bearpaw, Little Rocky, and Big Snowy Mountains in central Montana. Other significant topographic features include the Sand Hill region in central Nebraska, and southwestern New Mexico; the Badlands of west-central South Dakota; and the glaciated regions of northern Montana and North Dakota.

Most of the northern and southern temperate grassland drainage flows directly to the east, controlled for the most part by the original surface of the east-dipping sediments. Three principal plains levels and at least on remnant upland level dominate the landscape between the eastern and western boundaries of the grasslands. These form a set of steps ascending to the west.

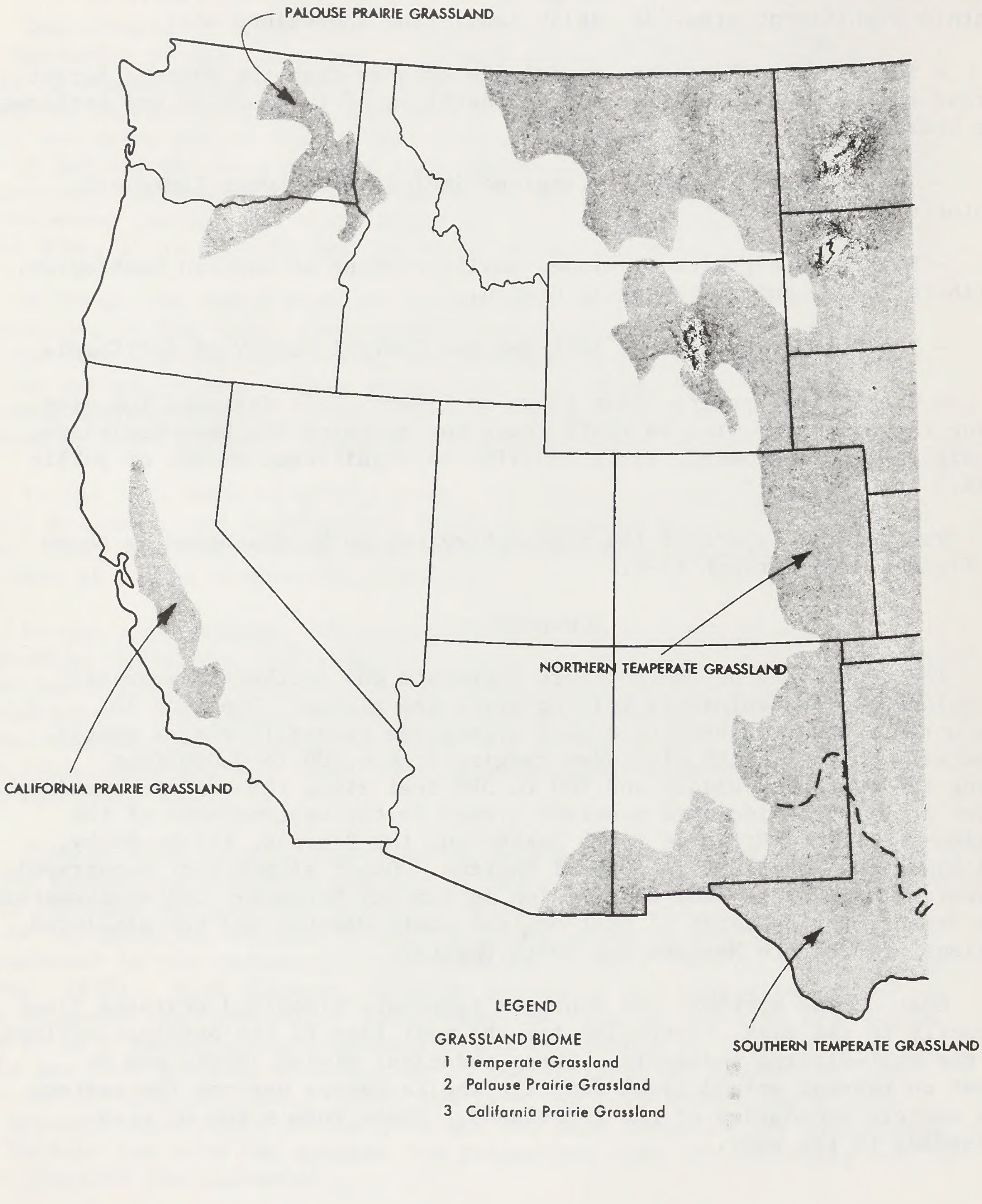


Figure II- 5
THE GRASSLAND BIOMES
IN THE WESTERN UNITED STATES.

Figure II-6. The Northern Temperate Grassland

Figure II-7. The Southern Temperate Grassland

Figure II-8. The Palouse Prarie

Figure II-9. The California Prarie

The Palouse prairie includes small portions of eastern Washington, northern Idaho, and northeastern Oregon. Topography varies from open hills and mountains to irregular plains and moderate to high-relief tablelands.

Soils

The soils of the northern and southern temperate grasslands vary considerably from north to south and from west to east. Only the soils in the western portion of the grasslands are described below. (Soil stability classes, the soil orders and series, and major soil characteristics are described in appendices I, J, and K.)

Along the Canadian border in Montana and North Dakota, the soils are the cool-moist, organic-rich Mollisols. In southern Montana, southwestern North Dakota, and northwestern South Dakota, soils are the warm-dry Entisols. In northeastern Wyoming, the mature warm-dry Aridisols predominate; in southwestern Wyoming and northeastern Colorado, the warm-dry organic-rich Mollisols are dominant. Southeastern Colorado has the warm-dry, mature Aridisol that are well formed with natural horizons. Eastern New Mexico has four warm-dry soils; the immature Entisols, the organic-rich Mollisols, the brown-to-gray-base Alfisols and the mature Aridisols.

The soils of the California prairie above the stream valleys are warm-dry Alfisols while those along the rivers and streams are warm-dry Entisols.

Palouse prairie soils are predominantly warm-dry Mollisols. At the junction of the Columbia and Snake Rivers, the soils are Entisols; farther up the Columbia, a small area of Aridisols has developed.

Minerals

A large portion of the oil and gas production of the United States is derived from this biome. Oil and gas exploration is very active with most of this activity confined presently to areas east of the Rocky Mountains. Commonly connected with the mineral activities are roads, pipelines, drilling sites, and small surface plants.

Water

The major surface waters in the grassland biome are the through-flowing rivers and streams of major drainage basins--the Missouri, western upper Mississippi, middle Arkansas, White, Red, lower Rio Grande, Texas-Gulf, middle Columbia-North Pacific, and the California Central Valley. The large rivers, the Missouri, Yellowstone, Platte, Arkansas, Rio Grand, Columbia, and Sacramento, receive most of their inflow from

the higher elevations above the grasslands. Many of the smaller streams within the more arid grasslands flow intermittently (U.S. Dept. of the Interior, 1970).

Annual runoff in the grassland biome ranges from less that 1 inch to more than 5 inches of water in much of the northern temperate grassland.

The total dissolved solids in surface water in the grasslands range from less than 100 parts per million (ppm) to more than 1,880 ppm. The amount of dissolved solids in a watercourse is affected by the type of soil and parent material in the region, the length of time the water has been in the watercourse, and the extent to which the flows are diluted by water from other sources. The specific chemical composition is an important consideration in determining whether water can be used for specific purposes. The total amount of dissolved solids in the water generally is the controlling factor in determining if a water supply is chemically suitable for most general uses,

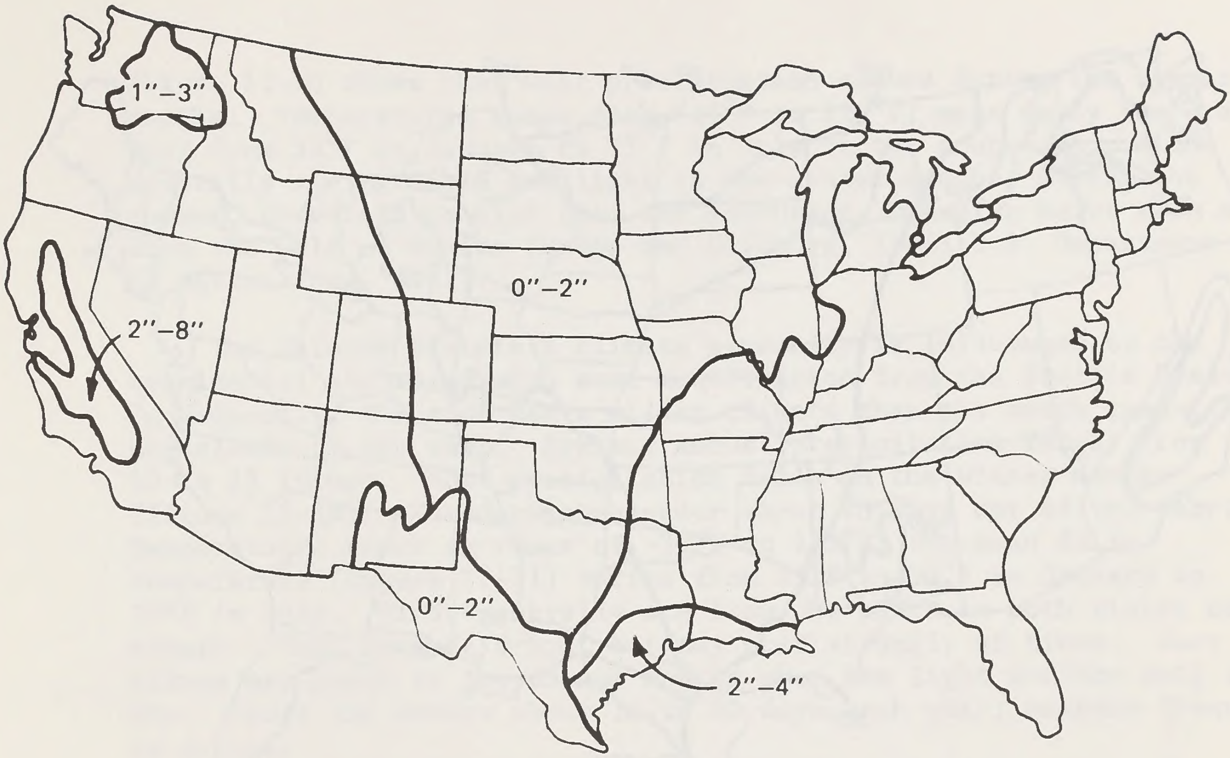
The average suspended-sediment concentrations in streams in the grasslands biome range from less than 230 ppm to more than 30,000 ppm. The suspended sediment in a stream comprises such particulates as sand and silt. Suspended sediment tends to be greater in areas where soil is not held in place by a dense vegetative cover.

The quality of water in most rivers, streams, lakes, and springs in the biome is adequate for most plant, animal, and human uses; however, localized pollution of water does occur.

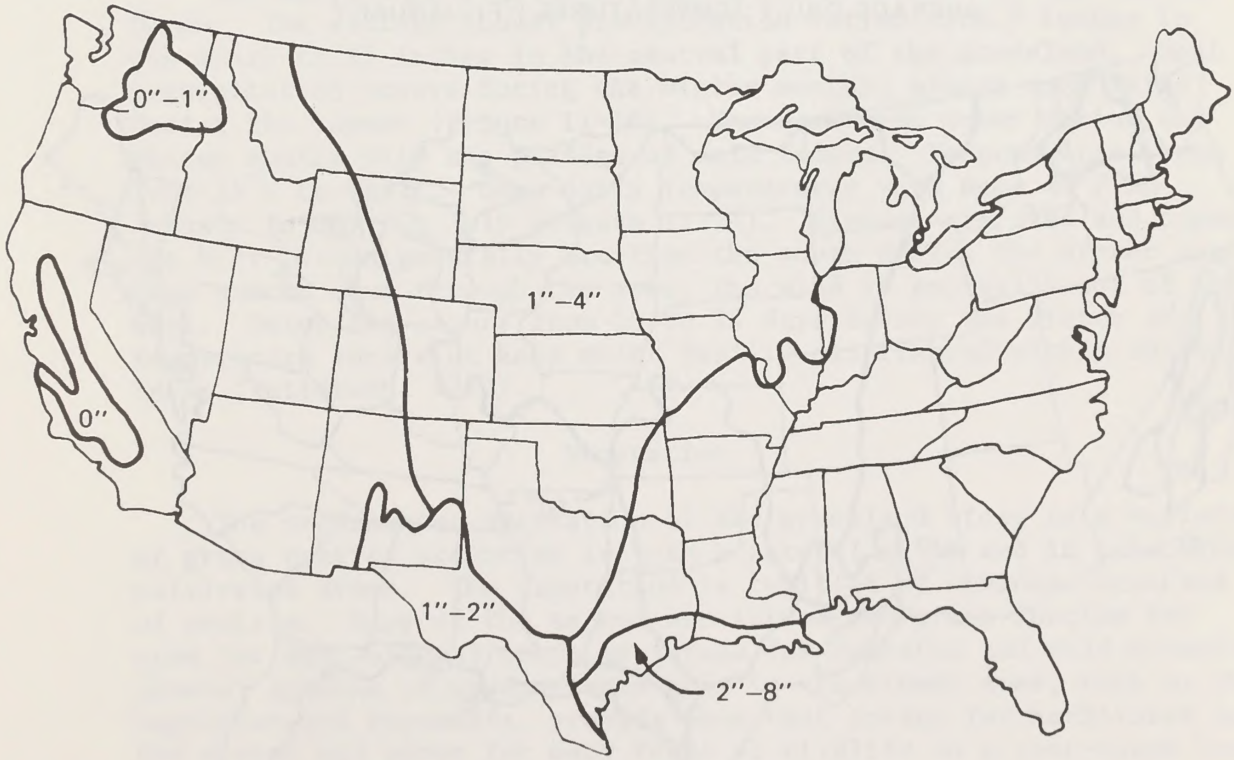
Climate

The northern temperate grassland has a continental climate. The average annual precipitation varies from 15 inches in the northwestern section to 30 inches in the southeastern portion. Seasonal precipitation varies from year to year. Most precipitation (figure II-10) occurs as rainfall from summer thunderstorms. Temperatures range from -40°F to 110°F. Mean daily temperatures vary from 0°F in January to 70°F in the northern section, and from 50°F in January to 80°F in July in the southern portion (figure II-11). Winds are generally from the northwest in the winter months; the average 10 miles per hour (mph), but range up to 40 mph or more and bring dry, cold air. In the summer months, dense fog occurs about 5 to 10 days each year. Humidity generally is low in the western portion and increases to the east (Odum, 1971; U.S. Dept. of the Interior, 1970).

The southern temperate grassland's climate is influenced by the continental air mass to the north and the humid Gulf of Mexico to the southeast. The average annual precipitation varies from 10 inches in the northwest to 40 inches in the southeast portion of the biome.

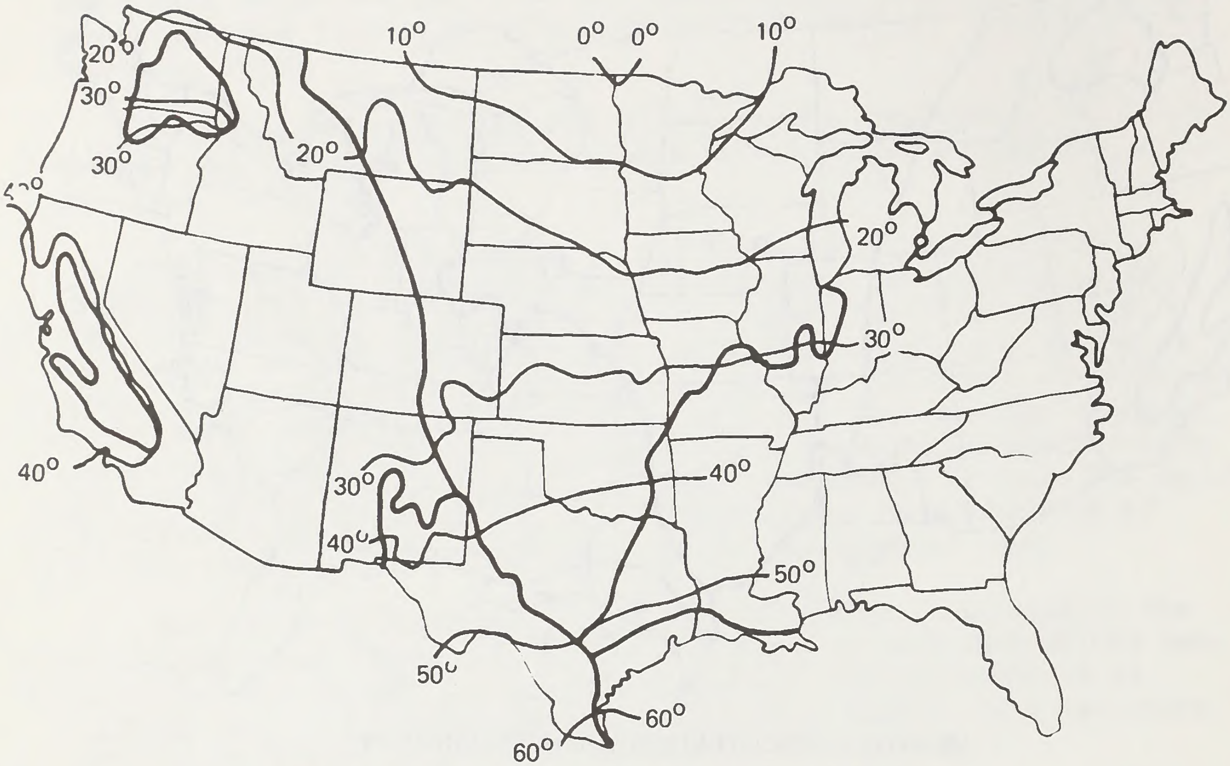


MONTHLY PRECIPITATION (INCHES)–JANUARY



MONTHLY PRECIPITATION (INCHES)–JULY

Figure II- 10 Average January and July precipitation in the grassland biome



AVERAGE DAILY TEMPERATURES (°F)–JANUARY

AVERAGE DAILY TEMPERATURES (°F)–JULY

Figure II-11 Average daily temperatures in the grassland biome in January and July

Figure 11-10 shows that most precipitation occurs during the summer months. Temperatures range from -10°F to 110°F; mean daily temperatures vary from 35°F in January to 75°F in July in the southeast. Winds generally are variable and light in the winter months; during the summer, they tend to blow from the southeast, bringing moist warm air from the Gulf of Mexico (Hodge and Duisburg, 1964; U.S. Department of Agriculture, 1941).

The Palouse prairie's climate generally is influenced by the continental air mass, with some modification from the Pacific Ocean. Consequently, the area has a milder climate than the north temperate grasslands to the east. Average annual precipitation ranges from 10 to 15 inches. Most precipitation falls in the winter months (figure II-10). Thunderstorms occur about 10 days out of the year. Temperatures reach extremes of -30°F to 110°F; the mean daily temperature (figure II-11) varies from 25°F to 30°F in January to 70°F in July. Winds generally are from the south in both winter and summer. They average 8 mph, but may gust strongly at times. Dust storms may occur in the summer months when the light surface soil is dry. Dense fog occurs about 10 to 20 days each year; maximum frequency in October.

The California prairie's climate is influenced by the Pacific Ocean. The average annual precipitation varies from 6 inches in the south to 23 inches in the central part of the grassland. Most precipitation occurs during the winter months; almost none falls during the summer (figure II-10). Thunderstorms occur during the winter months with the passage of cold fronts. Temperatures range from 15°F to 115°F. Mean daily temperatures vary from 40°F in January to 80°F in July (figure II-11). Winters are mild and summers are hot. Winds generally are from the south during the winter months. When storms move through the area, the wind is generally out of the west. Dense fog occurs from 10 to 25 days during the winter as temperature inversion keep moist Pacific air trapped within the valley basin (Pettersen, 1940).

Vegetation

The predominant vegetation of the grassland biome is a variety of grass species occurring in both a natural state and in extensive cultivated areas. The vegetation is typified by unbroken expanses of prairie. Many of the native and introduced grass species are used for agricultural crops or forage for domestic and wild animals. Several species of woody plants grow in the biome; some, such as the sagebrush and sageworts, provide important forage for herbivores in the winter and cover for many forms of wildlife on a year-round basis.

Grazing of domestic animals has been one of the major contributors to plant succession, particularly in increasing the distribution of woody plants and forbs. In addition to serving as an important food source, the grasses stabilize soils, minimizing water and wind erosion.

Grasses are remarkably adapted, both morphologically and physiologically, to grazing by herbivores. Grasses are unique in life form and growth. Adaptations to grazing include the zone of active growth tissue at the base of each blade and each node; buds in the axils of the sheaths of the lower portions of the stem, and positioning of the buds with respect to grazing and fire. Having evolved under grazing and being thus adapted to use by grazing animals, grasslands actually remain in better condition if properly grazed than if left ungrazed.

In general, the grasslands are located where rainfall is insufficient to support forestlike vegetation, but is sufficient to preclude the formation of a desert.

Marshes, lakes, ponds, and streams support various forms of aquatic vegetation. Algae are the most important producers in the freshwater environment. Except for pond and duck weeds, most higher aquatic plants are members of diverse families in which the majority of species are emergent.

The northern temperate grassland includes three broad perennial grass zones extending north and south across the western Mississippi Valley. The tall-grass prairie is located on the eastern edge of the grasslands; the mixed-grass prairie is intermediate; and the short-grass prairie extends along the western edge.

The southern temperate grassland most resembles the short-grass zone of the northern temperate grassland. It is the driest area in the grassland biome. Parts of it are dotted with desert shrubs because of the dry climate and overgrazing.

The Palouse prairie consists of midgrass species. In some areas, bunch grasses have been replaced by sagebrush. Large wheat crops are produced in portions of the region.

The California prairie originally consisted of midgrasses of the bunch-grass type similar in form to those of the Palouse. Many of the native grass strands have been replaced by annual grasses introduced from Europe. Parts of the Tule marshes along the major drainages have been converted to rice production.

A large number of forbs and a few grasses characteristic of the grassland biome are endangered with extinction. Typical examples are: Palouse thistle (cirsium brevifolium); brilliant mariposa (Calochortus nitidus) and indian ricegrass (Oryzopsis hymenoides var. contracta) (Federal Register, July, 1975).

Animal Life

The high annual turnover of net primary production in most grassland communities provides a food base for a large number and variety of animals. Many species are grazers, others are burrowers, and a large number of birds are ground nesters. Large herbivores are common throughout the biome. Insect life is abundant, varied, and heavily utilized as food by many secondary consumers. Every major animal phylum and many taxonomic groups of the plant kingdom are represented in the biome. Many of the animals are gregarious and frequently occur in large concentrations.

Droughts periodically occur in grassland communities, and the populations of some wild animal species can fluctuate widely from year to year.

Large domestic herbivores, such as horses, cattle, sheep, and goats, have largely replaced, or live in competition with, the native herbivores. Some of the joint use of rangeland ecosystems by domestic and native herbivores is compatible. Grazing significantly influences grassland ecosystems and, in doing so, has a decided effect on fire management. In many areas, plant cropping through grazing reduces light fuels, decreasing the fire hazard and rates of fire spread. Conversely, improper grazing has often caused changes in existing plant species which have significantly increased fuel volumes and flammability at certain times of the year.

Terrestrial Wildlife

Many animal grassland species warrant special considerations because of their particular needs. For example, a local population may require a specific site at a particular season to continue its life cycle, such as strutting grounds and adjacent nesting habitat for sharp-tailed grouse, sage grouse, or prairie chicken; and waterfowl and shorebird nesting areas around potholes, reservoirs, and marshes.

Some species extend their distribution into vegetal subtypes, and the local animal population becomes totally dependent upon the

restricted habitat. Some species, while not endangered throughout their range, have remnant populations in danger of being eliminated in local areas. The sharp-tailed grouse in the Palouse praire is an example. Local populations of some species are restricted to relatively small sites, such as prairie dog towns. Other species, such as the endangered black-footed ferret, are dependent upon the prairie dog as a primary food source and utilize the prairie dog burrows for homes.

The most conspicuous terrestrial wildlife are mammals and birds. In the northern temperate grassland, characteristic animals include pronghorn antelope, mule deer and white-tailed deer, whitetail jackrabbit in the north and blacktail jackrabbits in the south, prairie dog, ground squirrel, coyote, badger, ferret, pocket gopher; various waterfowl, prairie chicken, sage grouse, Swainson's hawk, rough-legged hawk, ferruginous hawk, burrowing owl, ground nesting birds such as the meadowlark and horned lark; bullsnake, rattlesnake, and an abundance of insects (U.S. Department of the Interior, 1952).

The southern temperate grassland includes many of the same animals found in the north. Other forms more common in the south include the antelope jackrabbit, desert cottontail, peccary, scaled quail, white-winged dove, scissor-tailed flycatcher, mocking bird, kingsnake, and several kinds of lizards.

In the Palouse prairie, the sharp-tailed grouse was abundant in the past. The short-eared owl, burrowing owl, and marsh hawk nest in the grassland. The cottontail and pygmy rabbit, pocket gopher, golden-mantled squirrel, and various grasshoppers are characteristic fauna.

In the California prairie, the California ground squirrel is one of the most characteristic species. The area is important wintering habitat for waterfowl. Many of the same animals, perhaps of different species, occur here as in other grassland areas.

Aquatic Wildlife

Aquatic wildlife includes fish and various invertebrates confined to a water environment such as shellfish. Aquatic fauna in the grassland area are less diversified than in the more humid regions. The natural distribution of nonmigratory fish is confined to water bodies with accessible and suitable spawning areas.

Anadromous fish species (examples--salmon, steelhead) utilize the river systems which pass through the Palouse prairie and California prairie grasslands for spawning purposes.

Warm water fish species occur in larger streams and warm standing waters. Examples include the shovelnose and lake sturgeons, paddlefish,

and gars of the Missouri River. Channel catfish inhabit small tributaries of the Missouri and some large reservoirs with warm, muddy waters. Bullheads are adapted to a wide range of conditions, but prefer warm streams or ponds. The black bass, blue gill, and perch occupy a wide range in relatively cool streams, lakes, and reservoirs. Cold water species in the high elevation, clear, spring-fed streams include various trout, mountain whitefish, grayling, suckers, and sculpins.

Endangered Wildlife

Several endangerd species of wildlife are characteristic of the grassland biome. These include: San Joaquin kit fox (Vulpes macrotis mutica); black-footed ferret (Mustela nigripes); American Peregrine falcon (Falco Pergrinus anatum); Mexican duck (Anas daazi); the bluntnosed leopard lizard (Crotaphytus silus); and the masked bobwhite quail (Colinus virginianus ridgwayi) (Federal Register, September, 1975).

Endangered fish species are found within the biome. Currently identified species include the Pecos gambusia (Gambusia nobilis), and greenback cutthroat trout (Salmo clarki stomias) (Federal Register, September, 1975).

Domestic Livestock

During the period of early settlement, the grasslands were used almost exclusively for livestock grazing. Today, beef, lamb, and wool still are the principal products of areas that have not been converted to crop production.

More cattle than sheep and goats are grazed on the grasslands because cattle are better adapted to the type of forage produced in most of the biome. Goats are limited, for the most part, to the bushier areas of the south temperate grassland. Sheep production is a significant land use in areas where shrub species are a prominent component of the vegetation.

Cattle numbers have steadily increased over the years, and sheep numbers have sharply declined. After a period of rapid decline, horse populations have remained fairly stable in recent years (U.S. Department of Commerce, 1947, 1965, and 1970).

Wild Horses and Burros

The population of wild horses and burros on public lands in the grassland biome is not significant when compared to the desert and

woodland-brushland biomes. In Montana, there are an estimated 250 horses with around 150 head in the Pryor Mountain Wild Horse Range. There are no known wild burros in Montana. A few wild horses and burros have been reported in the grassland biome of New Mexico. The population of wild horses on public lands in 1975 is estimated at 53,310 and wild burros at 6,970 (U.S. Dept. of the Interior, 1976).

Generally, it is recognized that burros and horses compete for both food and water with wildlife and domestic livestock.

Human Life

Demographic characteristics of the grassland biome vary considerably from one area to another. Most lands in the biome are rural. However, the biome also includes several large urban centers with significant differences in population densities, economies, and social environments. Nearly 17 percent of the total Western States' population lives in this biome.

Most of the counties in the biome are sparsely populated; densities over much of the area in 1970 were less than 10 persons per square mile, compared with a national average of 57.3 persons per square mile and a Western State average of 29 persons per square mile. Most of the rural areas lost population between 1960-1970, whereas, significant gains were experienced in most urban areas (U.S. Department of Commerce, 1971). The biome as a whole lost rural population at a greater rate than the Western States' average of 5 percent.

Income levels throughout the biome are generally lower than average for the West. When compared to the Western States' average, per capita income in the plains of New Mexico is only about 70 percent and Colorado and Wyoming Plains about 90 percent. The percentage of families under the poverty level is also generally greater (except in Wyoming) than the western average.

Low populations and other characteristics of the rural areas reflect economies geared to resource production and primary processing. Agriculture and agricultural production are principal economic activities. The isolation of resources from major markets has limited industrial growth in much of the area. The recreation-tourism industry has grown rapidly over the past 20 years and provided employment in the services sector of the economy.

Employment in agriculture is 4 percent of the work force for the 13 Western States as a whole. In the grassland biome, the percentages range from 4 percent in Colorado to 26 percent in northwestern Montana. However, livestock production makes up varying proportions of the agricultural sector. The percent of total income derived from livestock production is estimated to range from slightly over 2 percent in the Central Valley of California to nearly 12 percent on the Great Plains of Montana. Except for the California and perhaps Colorado portions of this biome, livestock production contributes relatively more to total incomes than in any other biome. The public lands supply 2,890,000 cattle AUM's (animial unit months) and 500,000 sheep AUM's to the livestock industries of the biome. These AUM's account for 8 percent of the total cattle and sheep feed consumed in the biome except for the southern grassland area of New Mexico, where it approaches 19 percent.

Small towns and villages are scattered throughout the rural areas of the biome. Towns with populations of 5 to 10 thousand are market centers and generally located along major transportation routes.

Urbanized areas located in the western portion of the biome in close proximity to extensive Federal lands include Great Falls and Billings, Montana; Boulder, Denver, Colorado Springs, and Pueblo, Colorado; Spokane, Washington; and the extensive Central Valley metropolitan complex in California. Metropolitan populations of each of the areas exceed 50,000. The Denver metropolitan area, for example, had a 1970 population of 1.25 million and a growth of 32 percent from 1960 to 1970 (U.S. Department of Commerce, 1971). If present trends continue, the prediction of an urban megalopolis stretching from Cheyenne, Wyoming, to Pueblo, Colorado, may be realized by the end of the century.

The metropolitan areas have combinations of capital, labor, services, and demand for products that support industrial development. The population concentrations support educational and cultural opportunities and a variety of housing and personal services. Economic and social environments are markedly different from those of rural areas in the biome.

Role of Fire

Fire was an important factor in the development of grasslands. But recognition of the importance of burning in determining the distribution and composition of vegetation has been slow to develop. Daubenmire and Daubenmire (1968) illustrated this earlier lack of recognition of the role of fire with this comment published in a scientific journal in 1926; "Scientific studies show conclusively that grassland fires gradually decrease the fertility of the soil by burning up the humus. They also reduce the vitality of the desirable grasses and weeds." Daubenmire

and Daubenmire observed that if one were forced to take an unequivocable stand on these points today, the mass of verifiable data that has accumulated makes the opposite of these statements more nearly correct. As quantitative data accumulate, the role of fire in grasslands has been approached in more objective terms.

Sauer (1950) reported that grasslands occur where there are dry seasons and where the land surface is smooth to rolling, thus, they are subjected to recurrent fires. These fires result in the reduction of woody vegetation. Exclusion of fire leads to gradual recolonization of woody species in many grasslands.

Lightning fires have undoubtedly been a factor in the grassland environment during a large portion of geologic time. In western and southwestern portions of the grassland, desert shrubs tend to encroach in the absence of fire. In wetter portions of the true prairie, numerous studies have shown increased forage yields as a result of burning (Daubenmire and Daubenmire, 1968).

Human Interest Values

Land Uses

The Homestead Act of 1862, railroad construction, irrigation, and other factors lead to the cultivation of vast areas in the grassland biome. Most lands remaining in a natural condition are unsuited for cultivation. Some are privately owned, but many of the western grasslands are federally owned. The uncultivated lands are extensively used for livestock grazing and outdoor recreation. Hunting, fishing, hiking, and other outdoor recreation activities are particularly significant on lands remaining in Federal ownership.

In the northern and southern temperate grasslands, the amount of agriculture and the percentage of private ownership decrease progressively from east to west. Cattle ranching and wheat farming predominate in the western section. A large portion remains undeveloped, providing significant recreation opportunities. Roadless sections with primitive qualities remain in some areas.

The California prairie contains productive irrigated agricultural land. Nuts, fruits, vegetables, rice, and specialty crops are grown in the area. Undeveloped areas are extensively used for livestock grazing and outdoor recreation. Outdoor recreation is a particularly significant use on some lands because of the proximity of large metropolitan areas.

Wheat grown by dry farming methods is the major agricultural use in the Palouse prairie. Significant areas in the western portion are irrigated; unirrigable portions remain undeveloped and are used for grazing.

Most metropolitan areas and some of the small cities in the biome are growing rapidly and using additional lands for residential, commercial, and industrial expansion. Inevitably, increased population concentrations place additional demands on adjacent rural and undeveloped lands for recreational uses.

Mineral extraction industries account for some land use. Oil and gas operations, and the mining of coal and some other minerals are quite active in this biome.

Aesthetics

The grassland may be described as primarily gently rolling hills and broad expanses of flatlands. In some areas near major streams, particularly in drier portions of the biome, continuity of the land may be interrupted by sharp breaks down to flood plains of the stream. Because of the relatively gentle slopes in the grasslands, few of man's activities interrupt continuity of the form. Where the form is disturbed, it is usually quite easily replaced to a natural or near-natural condition. Where the landscape is still in a natural state the soft texture of the grass-covered slopes is interrupted by occasional rock outcrops. In drier portions, ground cover may be in scattered patches with some exposed soil. Much of the eastern portion of the biome, along with the Palouse prairie and the California pairie, has been converted to agriculture. Here the texture changes from field to field as the crops change.

Although the texture of the grassland vegetation is easily disturbed, areas can recover rapidly if given the opportunity to do so.

Lines in natural portions of the biome play a minor role in the landscape and are evident only in ridgelines and in the occasional road or powerline crossing through the area. In the agricultural areas, lines become much more obvious. Crop rows, field edges, fence lines, and roads become a dominant element in the landscape.

Color is not a dominant factor in the grassland biome. It may play a more important role in moist agricultural areas, but in the natural and drier areas, the colors are green in the spring and early summer, light tan in the summer, and brown in the fall and winter. These are muted colors and tend toward monotones. Often, splashes of color break the monotony when favorable moisture enhances the growth of wildflowers. This often occurs following fire.

Scale is difficult to define on the flat plane of the grasslands. Any vertical element that is introduced into the landscape has a tendency to define the scale, but also draws the eye and becomes the focal point.

The total effect of the landscape character of the grassland biome will vary with the individual observer. To one, openness may connote a freedom, room for movement, a challenge to action. Another may feel overwhelmed, lonesome, and unprotected. To some, it may seem a monotonous wasteland. To the acute observer, subtle changes in tone or forms may be fascinating.

Sound and smell, although they may be an important factor in a very localized area, are impossible to describe for an entire biome.

Geological

Human interest in geological phenomena tends to center on the features that are different and strange or beautiful and exciting. Things like volcanic necks, caves with mineral formations, sinks, natural arches and bridges, fossils, and erosional features arouse the interest and curiosity of the viewer. The grasslands biome has some of these features but, being primarily a flat landscape, they are rather limited.

The northern temperate grassland has colorful heavily eroded areas like the Badlands of the Dakotas, dome mountains like the Little Rockies, canyons such as in the Missouri Breaks, fossil beds, and volcanic remains such Devil's Tower in northeast Wyoming.

The southern temperate grassland contains limestone caves in the Pecos River regions and sinkholes near Roswell, New Mexico.

The California prairie contains dome mountains (Marysville Buttes) in the vicinity of Sacremento and geologic faults with visible displacement, like the San Andreas fault along its eastern edge.

The Palouse prairie contains interesting geologic phenomena such as the scablands, the Grand Coulee, and other evidence of past volcanic action in the region.

Archeological

The biome contains archeological sites depicting the three broad developmental stages of American Indian prehistory. These are the Paleo-Indian, the Archaic, and Agriculture stages.

Both the eastern Big-Game Hunting Tradition and the Western Old Cordilleran Tradition occur within the biome. The Big-Game Hunting Tradition is recognized in kill sites of such animals as the bison, mammoth, camel, and horse. More rarely campsites are found with chipping and other animal debris. Some cave sites have been found. The Big-Game Hunting Tradition has been recognized in northern and southern temperate grasslands.

The Old Cordilleran Tradition represents a relatively unspecialized hunting-gathering-fishing way of life. Evidence comes from old lakeshore campsites, caves, and deeply stratified refuse dumps in favorite fishing spots. The tradition has been found in both the Palouse and California prairie grasslands.

The Archaic stage is found as a Plains Archaic Tradition in the northern and southern temperate grasslands. During this stage emphasis was placed on gathering of plants and some shellfish in addition to hunting.

In the Plains Archaic, this emphasis is indicated in the trash dumps, dry cave sites, burned rock debris mounds, and campsites. Bison and other animal kill sites continue to be found, some being buffalo jumps with rock alignments.

The Eastern Archaic is found in the eastern portion of the northern temperate grassland. It is similar to the Plains Archaic, but with more emphasis on gathering--especially shellfish.

The Desert Archaic Tradition is found in the southern temperate grassland and had some input into the cultures found in the California prairie. The Desert Archaic subsistence pattern was based primarily on small seed gathering and small animal hunting. Archeological evidence comes mostly from campsites, dry caves, petroglyphs, and pictographs.

The Agriculture stage is represented in the northern temperate grasslands by the Plains Culture (Woodlands and Plains Village Traditions). Although reverting to a strong hunting culture once again after the introduction of the horse in the 1700's, the Plains Culture base originally was

agriculture. Sites are predominantly surface and pithouse village sites (some stockaded), tipi rings and other rock alignments, pictographs and petroglyphs, caves, buffalo jumps and animal traps, log structures, vision guest sites, pole structures, and burial mounds.

The eastern portion of the northern temperate grasslands also contains remains of the Agricultural stage, Northeastern Woodland Tradition people with their temple and burial mounds, large village sites, and occasional cave sites.

Evidence of the Agricultural Pueblo Tradition can be seen in the northern portion of the southern temperate grassland. Evidence of the Pueblo Tradition, here represented by the Mogollon Division, includes sites of masonry buildings, pithouse dwellings, occasional irrigation systems, trash mounds associated with villages, pictograph and petroglyphs, caves, fortified sites, and roasting pits.

In the Palouse prairie, agriculture was never developed by the native inhabitants so that the final precontact periods are represented here by the Northwest Riverine Tradition. These people lived along the valleys and their archeological sites are mostly the remains of pit houses and above-ground houses in villages along the rivers, campsites, quarries, petroglyphs, and burial grounds.

Similarly in the California prairie, the Agriculture stage never developed and the Archaic stage continued up to the time of contact with non-Indians. Large shell middens occur near water, quarries, and village sites.

Historical

Historically, this region has seen early explorations and ownership by the Spanish, French, English, and Americans. During the fur-trading period, much activity took place and many trading posts were established. Army posts and camps constructed during the Indian wars were, in part, concurrent with the fur trade. Immigration, railroads, gold seekers and finally settlement by farmers and ranchers marked the conquest of the plains. These activities are marked by the remains and sites of old forts, trading posts, battle sites, cattle trails, railroads, mining ghost towns, homestead failures, and more recently, ventures in oil, gas and coal extraction, and water reclamation.

The northern temperate grasslands were considered, because of their dryness, and the Indians, as a barrier to movements to the more fertile areas of the West. Consequently, much of the history here involves Indians, Soldiers, and Immigrants passing through.

The southern temperate grasslands were explored in the 16th century by the Spanish, but little settlement took place. No real inroads into settling the various parts of the biome occurred until about 1850 with the advent of gold discoveries in California and the Rocky Mountain west.

The California prairie received some settlement in the Mexican Period, but its agricultural greatness began as a supplier of foodstuffs for the 49'ers. The Palouse prairie too was settled as an agricultural area in the mid-1800's.

Cultural

Most prominent of the minority groups occupying the grassland biome are American Indian Groups still living on the various reservations and using, to some extent, their lands for religious and cultural activities.

In the southwestern portion of the biome are Spanish-American communities whose lifestyle still depends on traditional land uses outside their villages.

Many of the native cultures attach religious or mythological significance to specific sites. Disturbances or intrusion upon these sites by others may seriously affect their religious values. Many other ethnic and religious groups have needs such as appreciation of their value system and recognition of their desires to be left alone.

DESERT BIOME

The desert biome in the United States occupies an extensive area between the coniferous forests in the Rocky Mountains, Cascades, and Sierra Nevada Mountains. It is found at elevations below the woodland-bushland vegetation. It includes two subtypes--cold deserts and hot deserts. The former have warm summers and cold winters; the latter have moderately warm winters and extremely hot summers. The locations of the two types of desert are mapped in figure II-12.

The cold desert extends through central Washington, eastern Oregon, southern Idaho, southwestern Wyoming, northeastern California, most of Nevada, Utah, northern Arizona, northwestern New Mexico, and extreme western Colorado. It includes islands and fingers of grassland and woodland types (Costello, 1972). Parts of it are referred to as High Desert, Great Basin Desert, or Painted Desert.

The hot desert extends through southeastern California, southern Nevada, southwestern Utah, and southern Arizona. Parts of it are referred to as the Mohave Desert, Sonoran Desert, and Chihauhuan Desert. The Federal Government owns much of the land in this biome.

LEGEND
DESERT BIOME
1 Cold Desert
2 Hot Desert

Figure II-12

DESERT BIOME

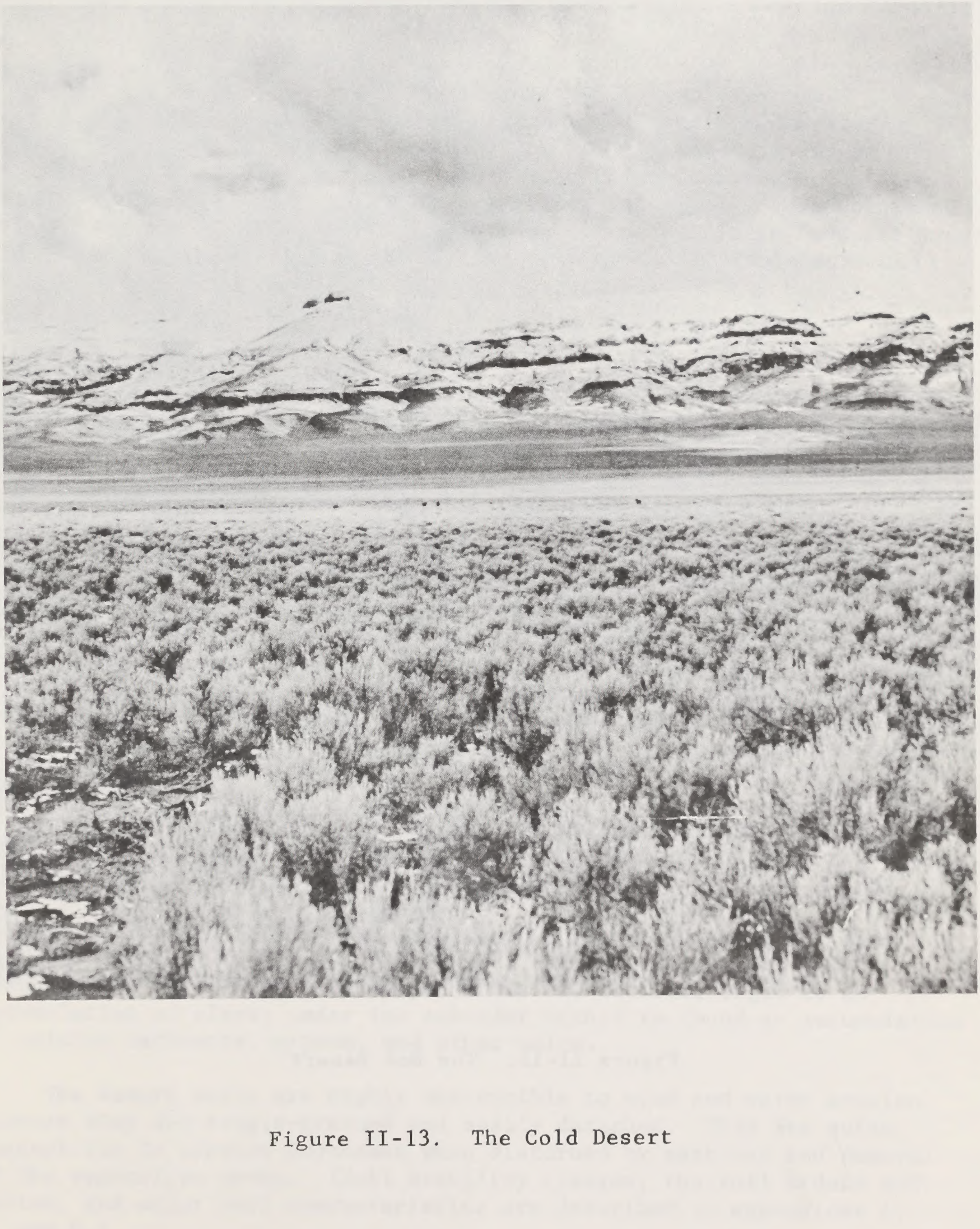


Figure II-13. The Cold Desert

Figure II-14. The Hot Desert

Typical landscapes in the cold and hot deserts are shown in figures II-13 and II-14.

Topography

Much of the desert in Arizona, California, Nevada, and western Utah is comprised of basins flanked by low to high mountain ranges. In southeast Oregon and southwest Idaho, the Columbia Plateau contains plains, medium to high hills, and high-relief tablelands. The Colorado Plateau in eastern Utah, western Colorado, northern Arizona, and northwest New Mexico is characterized by moderate-to high-relief tablelands and deep canyons.

Soils

The cold desert contains three soil orders. The dominant order is the Aridisols. The Aridisols occur in south-central Idaho, southeastern Oregon, central Washington, Nevada, and western Utah. These soils occur contiguously over a large area in the desert. Aridisols are dry for a prolonged period each year and have light-colored surface soils.

Mollisols are the second most extensive soils in the cold desert. They occur in eastern Washington and Oregon, southeastern and southwestern Idaho, central and southwestern Utah, and northeastern California. The Mollisols in the cold desert are dry for a prolonged period each year.

Entisols are young and essentially nondeveloped. Entisols are formed in recent alluvium, recently stabilized sand dunes or on steep slopes subjected to rapid soil creep. Entisols are located in south-central Oregon, western Nevada, and central Utah.

The soils of the hot desert biome are Aridisols. The soils in southeastern California, southern Nevada, and southern Arizona are hot, dry, and low in fertility.

The Aridisols contain two suborders: Orgids and Orthids. Both suborders have a hardpan or duripan, but differ in structure and composition. The hardpan developed under the suborder Orgid is an accumulation of clays; under the suborder Orthid is found an accumulation of calcium carbonate, gypsum, and other salts.

The desert soils are highly susceptible to wind and water erosion because they are single-grained and easily detached. They are quite susceptible to erosion processes when disturbed by machines and removal of the vegetative cover. (Soil stability classes, the soil orders and series, and major soil characteristics are described in appendices I, J, and K.)

Minerals

Most of the copper produced in the United States comes from this biome. Many very large, low grade deposits are being mined. Coal and phosphates are being mined in the eastern portion of the cold desert. Other mineral operations occur throughout the biome. These include, but are not limited to silica, gypsum, sodium, perlite, gold, mercury, trona, iron ore, and tungsten. Oil shale extraction may begin in the eastern part of the cold desert. There are areas where the existence of hot springs and rock temperature gradients suggest that energy may be developed from geothermal sources. These are primarily in southern California, Nevada, Oregon, and Idaho. The Federal Government has recently begun a program of leasing areas for geothermal developments.

Leasing and exploration activity is increasing, especially in the Great Basin portion of the cold desert. Nearly all of the current production of oil and gas in the desert biome is limited to the eastern edge of the desert in Wyoming, Utah, Colorado, and New Mexico. The soil is thin to nonexistent in large areas. There is more rock exposure on the surface than in the grassland and coniferous forest biomes. This feature attracts mineral prospectors and rock hounds and makes surface geological studies relatively easy and accurate.

Water

Parts of the Columbia-North Pacific, Great Basin, Upper Colorado, and Lower Colorado drainage basins are located in the desert biome. The major rivers of the biome are the Snake, Columbia, Humboldt, Green, and Colorado. They receive most of their runoff from precipitation in the higher elevations above the desert. Many streams within the arid desert biome are intermittent.

The Great Basin water resources region is a closed basin. Its surface waters drain into inland water bodies such as Great Salt Lake, Sevier Lake, Pyramid Lake, and Humboldt Sink.

Runoff from the desert is low and fluctuates widely from one year to the next. Average annual runoff ranges from less than 0.1 inch in the most arid section of the hot and cold deserts to more than 2 inches in less arid parts of the cold desert.

The quality of surface water in the desert biome is adequate for most purposes. However, in the lower Colorado region and Great Basin, some surface waters have high dissolved-solids content and/or suspended-sediment concentrations. Average dissolved-solids content ranges from less than 100 ppm (parts per million) in part of the Columbia-North Pacific region

to more than 1,800 ppm in some areas of the Great Basin and Lower Colorado regions. Average suspended-sediment concentrations range from less than 280 ppm in parts of the Columbia-North Pacific region to more than 30,000 ppm in northern Arizona and southwestern Utah.

Climate

The climate of the desert biome is characterized by low, erratic precipitation, strong winds (especially in the spring), and hot summer temperatures.

The cold desert lies in a belt of westerly cyclonic storms. The storms bring most of the annual precipitation to most parts of the cold desert during winter and early spring months (figure II-15). The average annual precipitation ranges from 4 inches in the desert valley to 16 inches on the higher plateaus.

Temperatures range from -20°F to 115°F. Mean daily temperatures range from 20°F in January to 75°F in July (figure II-16).

Mean wind direction and velocities vary little between winter and summer. Spring is the windiest time of the year, with winds of 40 mph not uncommon. Strong winds carrying sand sculpture the desert landscape. Temperature inversions cause blankets of fog to cover inland basins for several days at a time. In some areas, the inversions trap pollutants and pose serious air pollution problems for relatively short periods.

Infrequent frontal systems in the hot desert bring some moisture in from the west and north during the winter. During the summer, scattered thunderstorms drop moisture in the desert. Infrequent penetrations of moisture occur from the Gulf of California, the Pacific, and the Gulf of Mexico. The average annual precipitation ranges from 2 inches in the lower Imperial Valley to 8 inches in the remainder of the area.

Temperatures range from 25°F to 125°F. The mean daily temperature varies from 55°F in January to above 90°F in July (figure II-16).

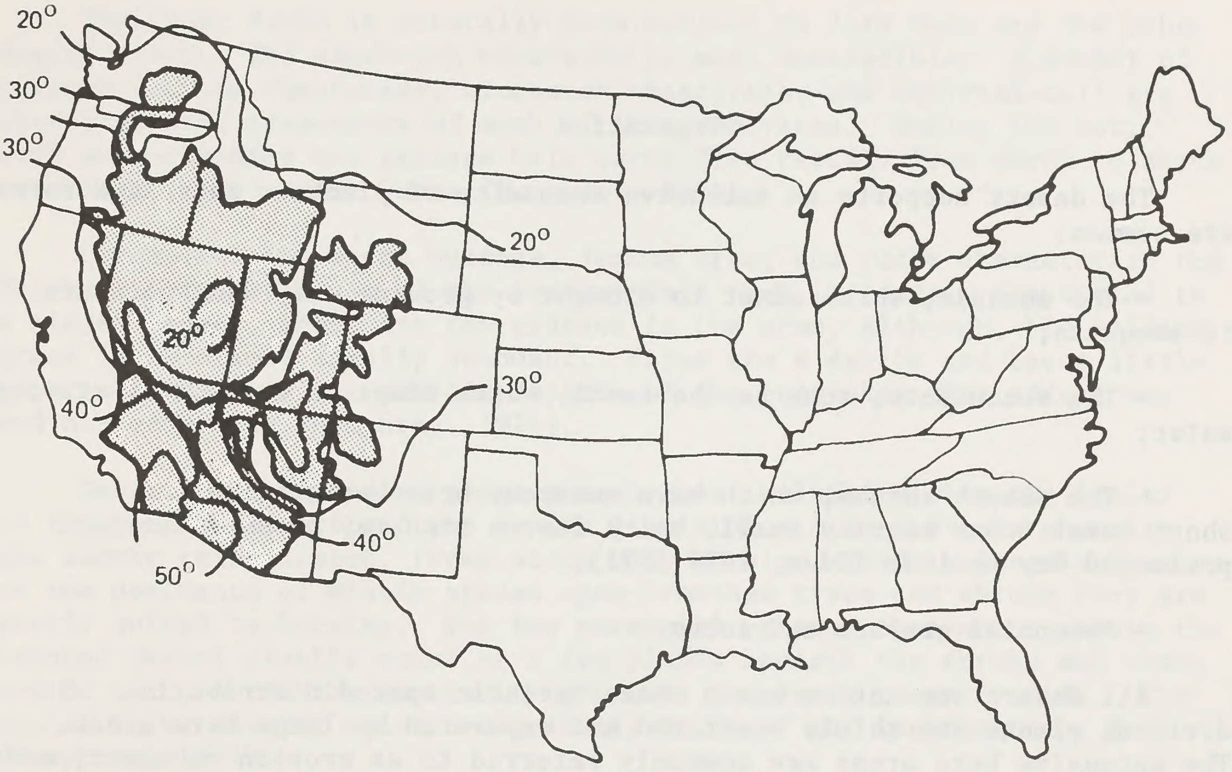
Spring months tend to be windy, and sand-carrying winds of over 40 mph are not uncommon. Late summer thunderstorms are more common in the hot desert than in all sections of the cold desert except central Wyoming. In that area, thunderstorms occur 40 to 50 days per year.

Climate varies widely from one area to another and from one year to another in the desert biome.

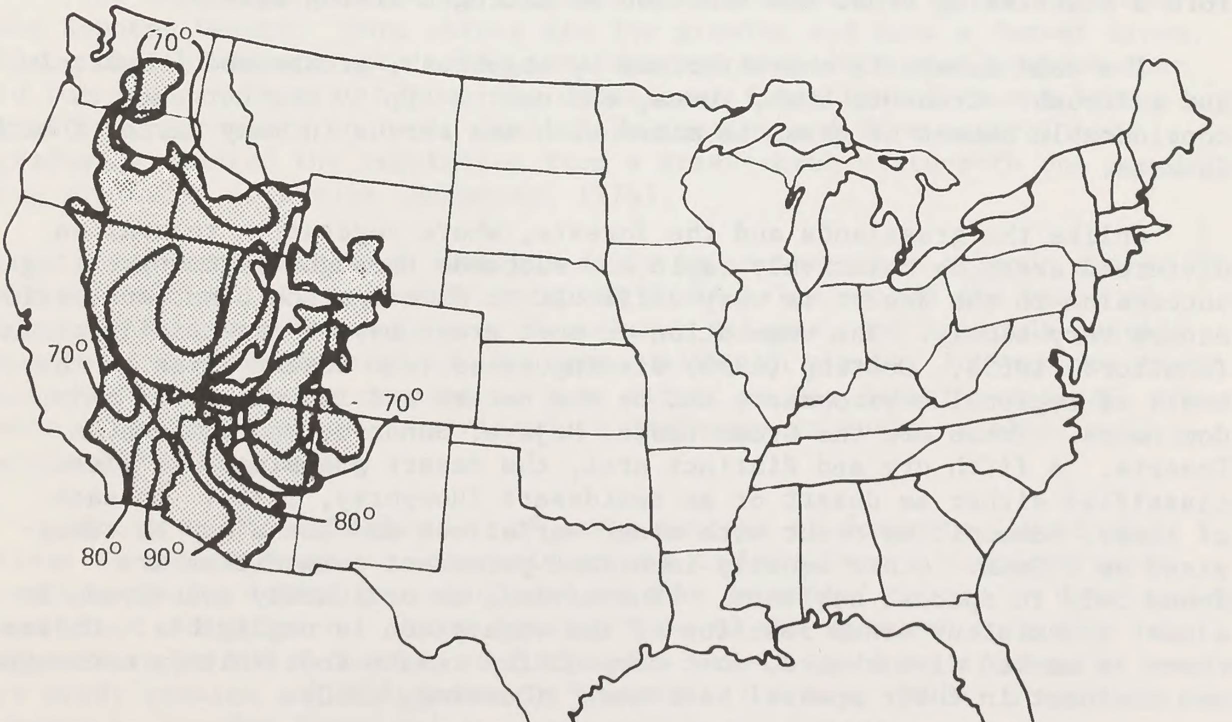
MONTHLY PRECIPITATION (INCHES)–JANUARY

MONTHLY PRECIPITATION (INCHES)–JULY

Figure II-15 Average January and July precipitation in the desert biome



AVERAGE DAILY TEMPERATURE (0°F)–JANUARY



AVERAGE DAILY TEMPERATURE (0°F)–JULY

Figure II-16 Average daily temperatures in the desert biome in January and July

Vegetation

The desert supports an extensive community of plants. Four life forms are common:

- The annuals, which adapt to drought by growing only when moisture is adequate;

- The succulents, such as the cacti, which adapt to drought by storing water;

- The desert shrubs, which have numerous branches originating short basal trunk bearing small, thick leaves that may be shed during prolonged dry periods (Odum, 1959,1971);

- Perennial grasses and forbs.

All desert vegetation has a characteristic spaced distribution. Individual plants are thinly scattered and separated by large bare areas. The extensive bare areas are commonly referred to as erosion pavement, consisting of soil and small pebble size rock. Mosses, algae, and lichens may also form a stabilizing crust and function as nitrogen-fixing agents.

The cold desert is characterized by sagebrush, greasewood, shadscale, and saltbush. Creosote bush, yucca, and cactus typify the hot desert. A considerable amount of grass is mixed with the shrubs in many parts of both deserts.

Unlike the grasslands and the forests, where vegetative renewal on disturbed areas is relatively rapid and succeeds through distinctive stages, succession in the desert is very difficult to detect since plant succession occurs very slowly. The vegetation on most areas may be essentially climax (Shelford, 1963). Oosting (1950) distinguishes four desert areas on the basis of regional environments and by the nature and importance of major dominants. These are the Great Basin, Mojave, Sonoran, and Chihuahuan Deserts. A fifth dry and distinct area, the desert grassland, is often classified either as desert or as semidesert (Humphrey, 1974). In each of these, communities occur with minor variations and these may be recognized as climax. Other equally important permanent communities are found only in special habitats. "Succession, as ordinarily conceived, is almost nonexistent since reaction of the vegetation is negligible. Unless there is marked disturbance, most communities remain indefinitely unchanged and dominant in their special habitats." (Oosting, 1950).

The Great Basin is generally more subject to fire than are the other desert areas. The sagebrush ecosystem is most susceptible. A number of grasses such as cheatgrass, bluebunch wheatgrass, and squirrel-tail are characteristic components of much of this ecosystem. During the hot, arid summer months the grasses help carry fire rapidly from shrub to shrub resulting in extensive burns (Humphrey, 1974).

Creosotebrush, white bursage, Joshua tree, and yucca characterize the Mojave Desert. Because of the low rainfall that is largely restricted to a winter season, there are few grasses in the area, although, big galleta grass is sometimes locally abundant. Fires are a rarity and cause little apparent damage to the various aspects of the ecosystem that affect man and his economics (Humphrey, 1974).

Despite the extensive geographical area included within the limits of the Sonoran Desert and the severe lightning storms that characterize the summer rainy season, fires occur only rarely. This is largely because of the dominance of widely spaced open-branched trees and shrubs that are poorly suited to burning. The few perennial grasses that occur within the Sonoran Desert usually occur as a few plants beneath the shrubs and trees and do not provide the continuity of cover necessary to carry fire. Pre-ennial forbs usually occur too sparsely to be of any importance as fuel (Humphrey, 1974).

The Chihuahuan Desert is slightly more susceptible to burning than the Sonoran Desert. More shrubs are low growing and have a denser crown. Also, the shrubs are more often interspersed with perennial grasses than in the Sonoran Desert. Thus, the occasional fires that do occur have a greater opportunity to run. Past close grazing and fire control have gradually changed the vegetation from a grass-shrub mixture to one consisting primarily of shrubs (Humphrey, 1974).

The desert grassland lies primarily in southeastern Arizona and southern New Mexico. It typically occupies broad belts around the bases of mountain ranges. Three genera, Boutelona, Hilaria, and Aristida provide most of the grass species of the type. Although shrubs, low-growing trees, and cacti were always present to some extent in the desert grassland, they were originally largely restricted to drainages or rocky, shallow soil areas (Humphrey, 1974).

Prior to the introduction of large numbers of domestic livestock, fires at rather frequent intervals appear to have been a characteristic feature of the desert grassland and were an important factor in determining the plant composition. Heavy grazing reduced the area and intensity of fires through the reduction of fuel. The result has been a dramatic increase in woody species and a decrease in grasses. Humphrey (1974) attributes the change to too few fires and too many cattle and horses.

A large number of endangered plant species occur in the desert. In the cold desert some examples are: loco weed, (Astragalus atratus var. inseptus, Astragalus sterilis); wild onion (Allium passeyi, Allium aaseae); busk wheat, (Erigeron latus); evening primrose (Primula cusickiana); and sandverbena, (Abronia orbiculata) (Federal Register, July, 1975).

Endangered plants in the hot desert include: agave (Agave utahensis var. nevadensis); loco weed (Astragalus mohavensis var. hemigyrus); and fleabane (Erigeron sionis) (Federal Register, July, 1975).

Animal Life

Terrestrial Wildlife

Animals have adapted to the environment of the desert in unique ways. Animal life in the biome is characterized by mammals which are fleet of foot.

More than 750 species and subspecies of birds and mammals live in the desert. Mule deer, bighorn sheep, pronghorn antelope, sage grouse, chukar partridge, and quail occur in suitable habitat of the desert. Carnivores in the desert are small and usually nocturnal. Species of kangaroo rat and pocket mice are found throughout the hot desert: both are nocturnal burrowers.

Wildlife of the Lower Colorado River Desert include the mule deer, bighorn sheep, jackrabbit, coyote, kit fox antelope ground squirrel, cave bat, big brown bat, leafnose bat, lesser nighthawk, roadrunner, and Gambel quail.

The sonoran Desert provides a habitat for mule deer, bighorn sheep the ringtail, spotted skunk, wood rat, peccary, Gila woodpecker, numerous small birds, bullsnake, three species of rattlesnake, and eight species of lizards. The Gila monster is typical of the tall-cactus community. The river bottoms and flood plains include some 32 kinds of birds.

The Mojave Desert has fewer species of pocket mice and the Gila monsters are of more limited occurence. Otherwise, many of the animals--with some differences in subspecies--are the same as those in the Sonoran Desert, with the desert iguana and desert tortoise being common. Death Valley, an example of desert habitat, has 39 desert mammals and approximately 100 species of birds (Shelford, 1963). Certain insect perform critical functions in the desert, such as Yucca moth that pollinates the Joshua tree.

Many of the desert animals are found in the sagebrush and shadscale of the cold desert. Major tenants, however, are the coyote, badger, pronghorn antelope, mule deer (locally), great horned owl, prairie falcon, Swainson's hawk, golden eagle, bald eagle, horned lark, and horned toad.

Aquatic Wildlife

Aquatic environments are limited in the desert biome. Diversions of water for agriculture and other uses have impaired some aquatic communities such as the fish habitat in Pyramid and Walker Lakes, Nevada --the home of Lahontan cutthroat trout and the depleted cui-ui sucker (Pacific Southwest Interagency Committee, 1974).

Water quality varies from the high quality desert-mountain snow water to such low quality alkaline lakes as the Salton Sea.

Desert aquatic environments have been altered by the construction of large reservoirs--Lakes Powell and Mead--and many small irrigation and stock watering reservoirs. Species such as black bass, crappie, carp, sunfish, coho salmon, and striped bass have been introduced in some reservoirs. Corvina, Sargo, and Bairdiella have been introduced in the Salton Sea. Most of these introductions have been successful while many endemic species have declined.

Endangered Wildlife

Many endangered species of wildlife are recognized in the desert biome. These include, but are not limited to: Utah prairie dog (Cyonomys parvidens); Sonoran pronghorn (Antilocapra americana sonoriensis); marked bobwhite quail (Colinus virginianus ridgwayi); Yuma clapper rail (Rallus longirostris yumanensis); southern bald eagle (Haliacetus leucocephalus leucocephalus); Amercian peregrine falcon (Falco peregrinus anatum); and desert slender salamander (Batrachoseps aridus) (Federal Register, Sept. 1975).

There are more endangered species of fish in the desert than in any other biome. This is due in part to the many isolated watersheds and the precarious nature of many water bodies. Typical species include: Devil's Hole pupfish (Cyprinodon diabolis); Owens River pupfish (Cyprinodon radious); Woundfin (Plagopterus argentissimus); Pahrump killifish (Empetrichythys latos); Gila topminnow (Poeciliopsis occidentalis); and Colorado River squawfish (Ptychocheilus lucius).

Domestic Livestock

The desert biome produces a variety of forage species suitable for domestic livestock forage. Both cattle and sheep are grazed throughout the biome.

Because of variations in climate in the cold desert, livestock grazing may occur during any season depending on location. In the northern third of the biome, livestock grazing is very limited in the winter seasons because of severe winter storms. Spring and fall grazing is most common and some winter grazing of sheep occurs where the climate permits.

Parts of the hot desert are grazed by cattle yearlong. Some sheep

grazing occurs, but it is limited to the winter season.

In about one year out of five, unusually abundant precipitation in the hot desert produces a good crop of winter annuals. Livestock grazing increases during the brief period the annuals are available.

Although forage is especially suitable for sheep grazing, the number of sheep in the desert has declined over the years generally because of economic factors.

Past trends in the number of sheep have definitely been downward throughout the desert biome. Between 1964 and 1969, the 13 Western States experienced an 11-percent decline in sheep numbers. The most likely explanation lies in consumer preference for other types of red meat and the substitution of synthetic fibers for wool. Other factors affecting the sheep industry are high labor costs, loss to predators, real estate opportunities, and social mores.

Wild Horses and Burros

Bands of wild horses and wild burros roam several ranges in the hot desert uplands and remote areas of the cold desert.

The greatest numbers of wild horses and burros on public land occurs in the intermingled cold desert biome and the pinon-juniper type of the woodland-brushland biome. About 90 percent of the estimated 60,100 wild horses and burros occur in this association; Nevada has the most and the widest distribution. Competition with livestock and wildlife for forage is common. An estimated 5,000 wild burros populate the hot desert region of Arizona, California, and Nevada, and compete for forage with wildlife and livestock.

Human Life

About 17 percent of the Western States' population resides in this biome. Except for the hot desert region of southern Nevada, California, and Arizona, the desert biome has one of the lowest population densities in the West--around five persons per square mile. Urban populations are clustered around the major trade and service centers such as Phoenix, Salt Lake City, Las Vagas, Reno, Boise, and the urban areas of California.

In the rural areas, per capita income levels are about 85 percent of the western average, but relatively fewer families are below poverty levels due to lower living costs. In spite of the low incomes, most of the biome experienced a net population gain during the 1960-70 period. Population increased from 1960 to 1970 by 29 percent or an average annual increase of 2.9 percent, which is slightly above the Western States' average.

The entire area is dependent upon a limited water resource. Principal industries in rural parts of the biome are agriculture and mining. Urban centers tend to be new and modern, with growing manufacturing and service-oriented industries. The Reno and Las Vagas areas have expanded entertainment and tourist service into a major industry.

One of the reasons for significant population and economic growth in the biome during recent years has been its "amenity" resources: clear air, warm weather, cloudless skies, low population, and ready access to outdoor recreation areas. Tourism and recreation are growing rapidly. Subdivisions and sale of lands for retirement or recreational use are mushrooming in many rural areas. In urban areas, the quality environment, ready access to consumer services, educational institutions, and a labor market form a magnet for industries for which ties to raw materials sources or national market centers are not major constraint. Typical of these are apparel, electronics, and aircraft industries (Friedman and Alonso, 1964).

Due to the range livestock industry, the desert biome ranks between the grassland and coniferous forest biomes in terms of local economic importance. In this biome, the livestock industry is relatively dependent on public lands as a source of forage. For example, in Great Basin Area (central and northern Nevada, western Utah, and southwerstern Idaho, and southeastern Oregon, the public lands account for about 60 percent of the total livestock feed. Livestock operations are less dependent in the hot desert where public lands account for about 38 percent of the land area and provide 3 percent of the feed consumed. The high concentration of feedlot operations in the latter area accounts for much of the difference between the two sub-biomes. For the biome as a whole, the public lands supply 5,990,000 cattle AUM's and 1,970,000 sheep AUM's.

Role of Fire

Wildfire in the cold desert is common. Most people, however, would not consider the hot desert to have been influenced by fire because the sparsely scattered vegetation appears incapable of supporting fire; but Vogl (1967) found it difficult to accept that such a vast and varied area could have escaped the influence of fire. He believed the incidence of fire possible because desert vegetation is highly flammable and subject to periodic lightning. Thus, only infrequent fire would be necessary to produce pronounced effect, since plant succession is slow in the extremely harsh and dry desert environment.

A desert grassland type occurs in parts of the Sonoran Desert in Arizona and has been considered a fire type (Humphrey 1962). Vogl (1967) cited fire influences on fan palm oases, desert scrub, and desert woodlands. Fires limit the dominance of pinon pines and junipers in the desert woodland, and at the same time appear important in the production and maintenance of pure Joshua tree stands.

Cable (1972) summarized the results of over 20 years of research on the effects of burning on semidesert grasses and shrubs in southern Arizona, indicating that shrubs are most susceptible to burning in June. Some shrub species are highly susceptible to burning, others are relatively resistant, and others are intermediate. The lack of sufficient herbaceous fuels in most years often limits the scope of fire effects on shrubs. Cacti are moderately susceptible to fire, depending on presence of sufficient fuel.

Human Interest Values

Land Uses

Most of the land in the desert biome is owned by the Federal Government. Extensive areas are used for military operations and other Government purposes, such as bombing ranges, atomic test grounds, possible power sites, and possible reclamation projects. Most of the Federal lands in the biome are public lands administered by the Bureau of Land Management.

The native vegetation covering a major part of the biome is used for livestock grazing, the most extensive agricultural activity in the biome. Both cattle and sheep are grazed in the desert. The former are primarily cow-calf operations; the latter are oriented toward lamb production. Natural vegetative productivity for grazing decreases, generally, from north to south in the biome. Parts of the hot desert are marginal grazing lands, and some areas are unsuitable for livestock use.

Irrigated crops in the cold desert include potatoes, sugar beets, grains, and hay. Subtropical fruits, cotton, and specialty crops are grown in the hot desert. Large areas of irrigable soils remain unirrigated in the desert because of inadequate water supplies.

A few areas in the biome have been formally designated and managed as wilderness, primitive, or roadless areas. Additional areas containing native vegetation and lacking significant development (such as roads, buildings, or other facilities) may be considered for formal designation as land-use planning progresses.

Mining was responsible for much of the original settlement of the biome. Many of the early towns started as gold or silver camps. Mining continues today to be an important industry in the States of Colorado, Arizona, New Mexico, Utah, Wyoming, Idaho, and Nevada. The exploration and production of oil and gas is important to the economy and environment in the desert biome.

The desert is extensively used for outdoor recreation. Heaviest use occurs near large population centers. The western part of the hot desert to the Los Angles-Las Vegas-Phoenix urban areas receives extremely heavy use.

The limited surface waters in the biome are heavily used for recreation activities. Heavy offroad vehicle use is occurring close to urban areas.

Metropolitan areas in the desert have grown rapidly in recent years. The Las Vegas urban population increased 165 percent between 1960 and 1970 (U.S. Department of Commerce, 1971). The urbanized area increased from 35 square miles to 131 square miles. Other metropolitan areas such as Phoenix and Salt Lake City experienced similar growth. The extraordinary growth of metropolitan areas in the desert may continue for several decades. If so, large areas of adjacent rural land may be required for expansion.

Urban areas in the biome are separated by vast areas of open space.

Smaller cities serving a local market area or developing a tourism-recreation industry probably will experience an increased demand for residential, commercial, and industrial land uses.

Demand for recreational or retirement homesites in remote areas probably will continue to increase.

Aesthetics

The term "desert" for many people carries with it a connotation of sand dunes and desolation. While it is somewhat inhospitable for man, the connotation is far from accurate. It may, however, be partly responsible for the lack of development and use of the desert in the past. People are just now discovering the desert for the wide variety of interest it really has. There are sand dunes in both the cold and hot deserts, but they involve a very minor part of the area as a whole. The dunes are one more interesting facet of the desert that people are finding more and more enjoyable.

Although there are many similar characteristics throughout, the desert biome can be more clearly described in the two separate sections.

The landform of the cold desert is typically the flat dry bed of an ancient lake or the relatively low rolling hills of the Great Basin, occasionally interrupted by a small mountain range. In southern Idaho and Oregon, the landform is broken by considerable areas of rimrock and often cut by deep canyons. Seldom is the observer out of sight of a mountain somewhere in the area of view. Texture of the cold desert is generally the relatively soft texture of the vast expanses of sagebrush broken occasionally by a bare ridgeline, a steep gully, or a flat dry lakebed.

Except for dawn and sunset, color is rather monotonous in the cold desert. It is generally dominated by the gray-green of sagebrush or the flat grays and browns of the soil typical to the region. Soil color becomes a more important factor in some portions of the cold desert such as in Wyoming, Colorado, and New Mexico where the red sandstones make up the parent material.

Lines play a very minor role in the makeup of the character of the cold desert. Lines that are evident are primarily those caused by man, roads, fences, and powerlines that occasionally cross through the area. Although these intrusions are few, they are obvious for many miles.

As in the grassland, scale is difficult to define. Vastness of open space with few vertical elements in the landscape makes it hard to tell just how far an observer is from a given object.

The character of the hot desert is considerably different from that of the cold desert. Form is more often remnants of eroded mesas with flat valley bottoms. Where live streams run through the desert, they often are actively eroding the land; and steep, sometimes vertical-walled canyons are incised into once flat mesas. Prime examples of this area are the canyons of the Lower Colorado River.

There are distinct horizontal and vertical lines evident in the mesa tops and sharp dropoffs to the valley floors. Color becomes a dominant factor in the hot desert. Rich reds and browns of exposed soil and rocks are much more in evidence than in the sage-covered cold desert.

Texture is fairly coarse because of the widely scattered vegetation. Rock and soil are exposed over much more area.

Scale is much easier to define in the hot desert. Vertical lines created by edges of eroding mesas along with the larger and more scattered vegetation provide the observer with the elements needed to judge size and distance more accurately.

Sounds are quite important in the desert biome. The fact that sound travels great distances because of sparse vegetation and long uninterrupted stretches of topography is important to the visitor. In many areas, silence is unique to the desert.

Geological

Deserts have some of the most monotonous geological features and some of the most intriguing. The basin and range areas of Nevada tend to be somewhat repetitive with long sweeping views of the basins and short quick trips through the mountain ranges.

Certain areas, particularly the Colorado Plateau, are highly eroded, mostly in colorful formations that contain delicate erosional features, easily recognizable "picture book" geological structures, and grand views. Scattered throughout the biome are some of the most magnificent canyons in the world, the Grand Canyon, the canyons of the Snake, the Owyhee, the Green and others. Also present are sand dunes, volcanic features, playas, and fault structures.

Archeological

In the desert biome are found remanants of both Big-Game Hunting Tradition and Old Cardilleran Tradition cultures, the former to the east and south and the latter to the north and west. Hunters in southeast Arizona hunted mammoths along with other big game. People in the Nevada Desert were mostly gatherers, but did hunt small game, including waterfowl, around the many Pleistocene lakes in the region.

These two traditions developed into what is termed "the Desert Culture Tradition," a basic gathering culture that existed on many grasses, pinons, insects, small game, and other products of the hot and cold deserts.

From this Desert Archaic base there developed, as the result of strong influences from the valleys of Mexico, several agricultural cultures in the hot desert and the southern portions of the cold desert.

Irrigation farming was practiced, large communal structures constructed, and highly organized and structured social systems developed. At the same time period, there also were people with the Desert Archaic Tradition still coexisting and others like the Apachean groups moving into the desert area. This was the situation at the time of the first non-Indian contact (by the Spanish explorers) in the early 1500's.

Large archeological sites of the desert biome are quite easy to detect, but attention paid to these sites tends to allow other, less pretentious sites like agricultural terraces, campsites, chipping areas, small canals, and shallow caves to be destroyed.

There is almost a one-to-one relationship between archeological sites and water sources in the desert. Water sources were as important to prehistoric man as to modern man.

Historical

Like most of the West, history of the desert biome is generally so recent that some individuals still living there have seen many of the important historical events that have taken place.

Most of the settlement has taken place in the last 100 years. Only in southern parts of the hot desert is civilization older, due to the Spanish and Mexican settlement. The Great Basin portion of the cold desert is the least inhabited area in the country, with history revolving around minimg ghost towns and the ranching industry. In the hot desert, irrigation agriculture has been a way of life from prehistoric times. Other than these influences, historical values are similar to those of the grasslands.

Cultural

There are some interesting cultural-ethnic and religious groups in the desert biome. Throughout the Western United States a "cowboy" culture predominates in many areas. In Nevada and southwest Idaho are groups of Basques originally brought to this country as sheepherders from the Pyrenees Mountains of Spain. In Utah, and parts of Arizona, Nevada, Idaho, and Wyoming are concentrations of Mormans, a religious group which is a minority in the United States, but a majority in the desert biome.

The Yaquis near Tucson are native Americans living here as a political refugee group from Mexico. A great number of native Indian Americans live on reservations in the biome. These range from farmers like the Pimas and Papagos to hunting-gathering peoples like the Yavapai and Paiutes. All of the Indian groups have a strong attachment to the lands around their areas of settlement.

WOODLAND-BUSHLAND BIOME

The woodland-bushland biome occurs in many parts of the Western United States. It is discontinuous, occurring as biological islands at higher elevations within the grassland and desert biomes. It also forms a transitional zone between those biomes and the coniferous forest biome. Its general range is shown in figure II-17. Many of its vegetative characteristics are similar to the cold desert. Figures II-18, II-19, and II-20 illustrate the oak woodland-bushland, pinon-juniper, and the broad sclerophyll communities, the three-species associations in the biome.

Topography

Much of the woodland-bushlands are located on the high hills and mesas in and adjacent to the deserts.

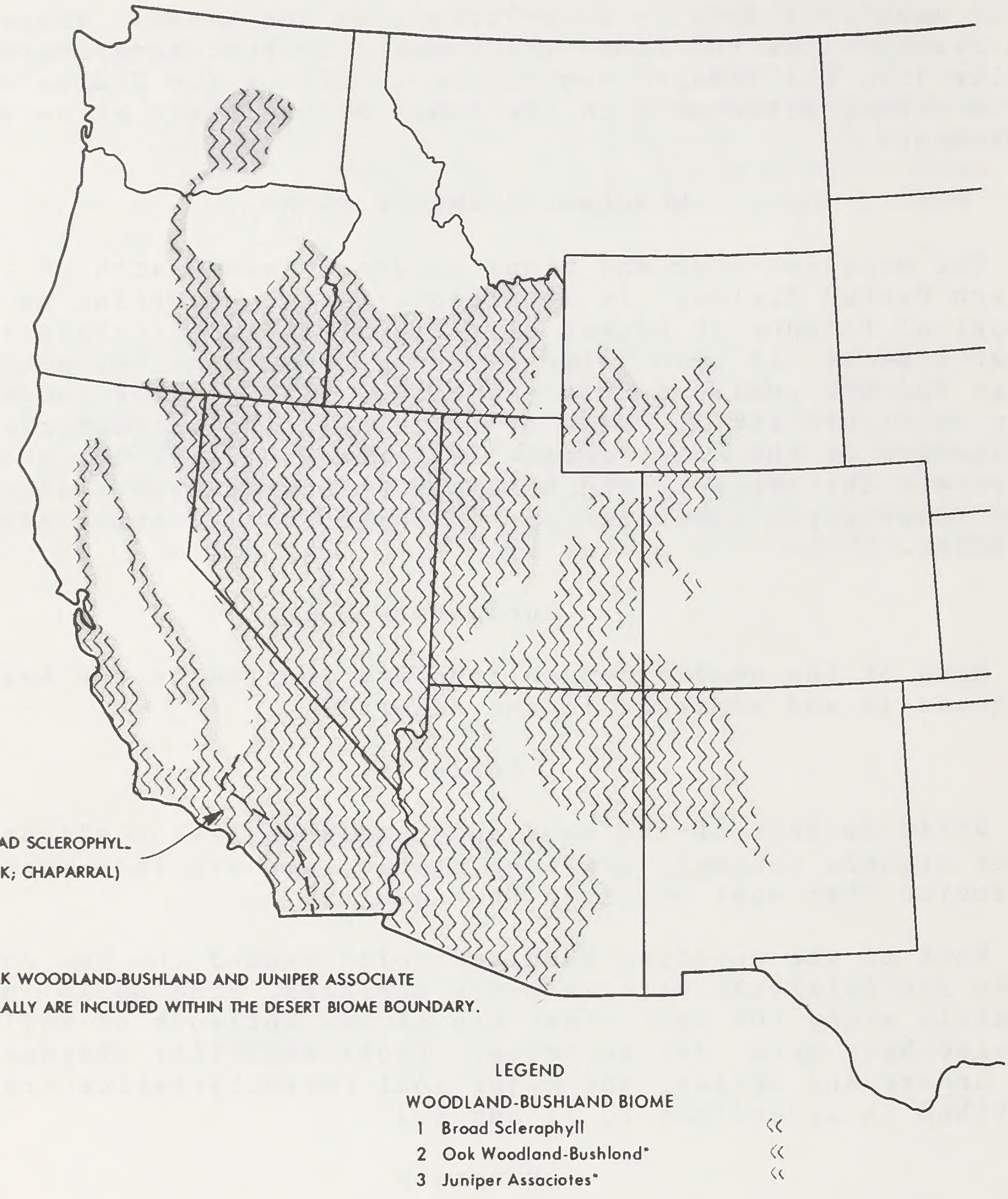
Soils

Soils in most of the woodland-bushlands have a slightly higher organic content, are more stable, and are less susceptible to erosion than most soils in the desert.

Most of the woodland-bushland soils around the San Joaquin Valley are Aridisols with warm-dry surfaces. The soils in the foothills along the west coast are either Entisols or Mollisols and also have warm, dry surfaces. (Soil stability classes, the soil orders and series, and major soil characteristics are described in appendices I, J, and K.)

Minerals

Coal occurs in parts of eastern Utah, Colorado, Wyoming, and New Mexico. Deposits of uranium also occur in these areas. Vast deposits of oil shale occur in Colorado, Wyoming, and Utah. Oil and gas found in Wyoming and in the four-corner area of Colorado, Utah, Arizona, and New Mexico. Other oil and gas



(*Generally included within the desert biome boundary.)

FIGURE II-17 WOODLAND-BUSHLAND BIOME

Figure II-18. The Oak Woodland-Bushland Community

Figure II-19. The Pinon-Juniper Community

Figure II-20. The Broad Sclerophyll (Oak-Chapparal) Community

fields are scattered throughout the biome. The famous mother lode country of California is in the bushland region of the biome.

Water

Water resources vary considerably from one area to another in the woodland-bushland biome. Most of the surface water is supplied by rivers and streams with headwaters in the forests above the woodland-bushland.

The woodland-bushland areas generally receive from 12 to 25 inches of mean annual precipitation; however, the California oak-chaparral receives up to 50 inches per year. Both intermittent and perennial streams are found in the woodland-bushland areas. The intermittent streams are particularly common in juniper woodlands. Floodwaters of intermittent streams generally carry considerable silt. High-intensity summer thunderstorms are typical of the juniper areas and flood runoffs are common.

Where annual precipitation averages from 10 to 15 inches per year, annual runoff ranges from 0.1 to 5.0 inches per year. Where an average of 15 to 25 inches of precipitation falls per year, annual runoff may range from 0.5 to more than 10 inches. In the California oak-chaparal area, average runoff may be as high as 20 inches.

The quality of most surface waters within the woodland-bushland areas is generally acceptable for most uses. However, some streams in juniper areas have a high silt content. Average dissolved-solids content in surface waters ranges from less than 100 parts per million (ppm) to more than 1,800 ppm. Average sediment concentration of streamflow varies from less than 280 ppm in the oak woodlands to more than 30,000 ppm in some of the juniper associate areas.

Climate

Climate conditions vary significantly within the woodland-bushland biome. The woodlands east of the Sierra Nevada range are comparatively dry because of the mountains' rain-shadow effect; woodlands in the California foothills are influenced by moisture-laden marine air.

In the woodlands on the foothills above the cold desert, about 75 percent of the annual precipitation falls during the winter. In the woodlands above the hot desert, the precipitation is somewhat even throughout the year; months of July and August bring the most rain. The average annual precipitation ranges from 10 to 20 inches (figure II-21).

Temperatures range from 20° to 100°F; the mean daily temperatures vary from -20°F in January to 85°F in July (figure II-22).

Windiness, especially in the spring, is characteristic of the woodlands in the desert foothills. Dust devils frequently accompany thunderstorms on hot days. Winds of 40 mph are not uncommon. Fogs usually occur only in small basins.

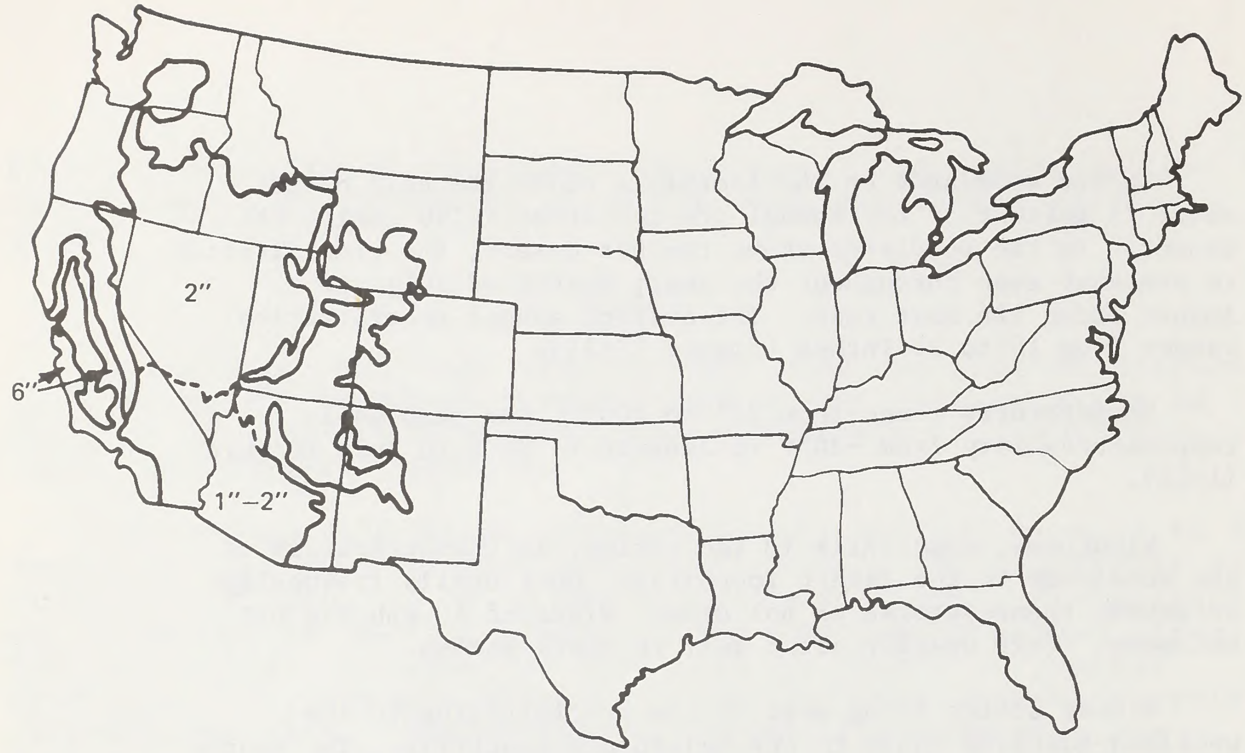
Winter storms bring most of the precipitation to the woodland-bushland lands in the California foothills. The months of June, July, August, and September are dry. Average precipitation ranges from 20 to 40 inches in the north and from 10 to 20 inches in the south.

Temperatures in the California foothills range from 5°F to 112°F; mean daily temperatures range from 45°F in January to 70°F in July (figure II-22). Winds generally are light and from the south during the winter except during the passage of storms, when winds frequently exceed 80 mph. During the summer, winds are out of the northwest at about 5 mph.

Fog occurs only during the winter in the woodlands in the California foothills and only in small valleys where air becomes trapped by topography. Thunderstorms occur about 5 days out of the year, generally in the late spring or early fall.

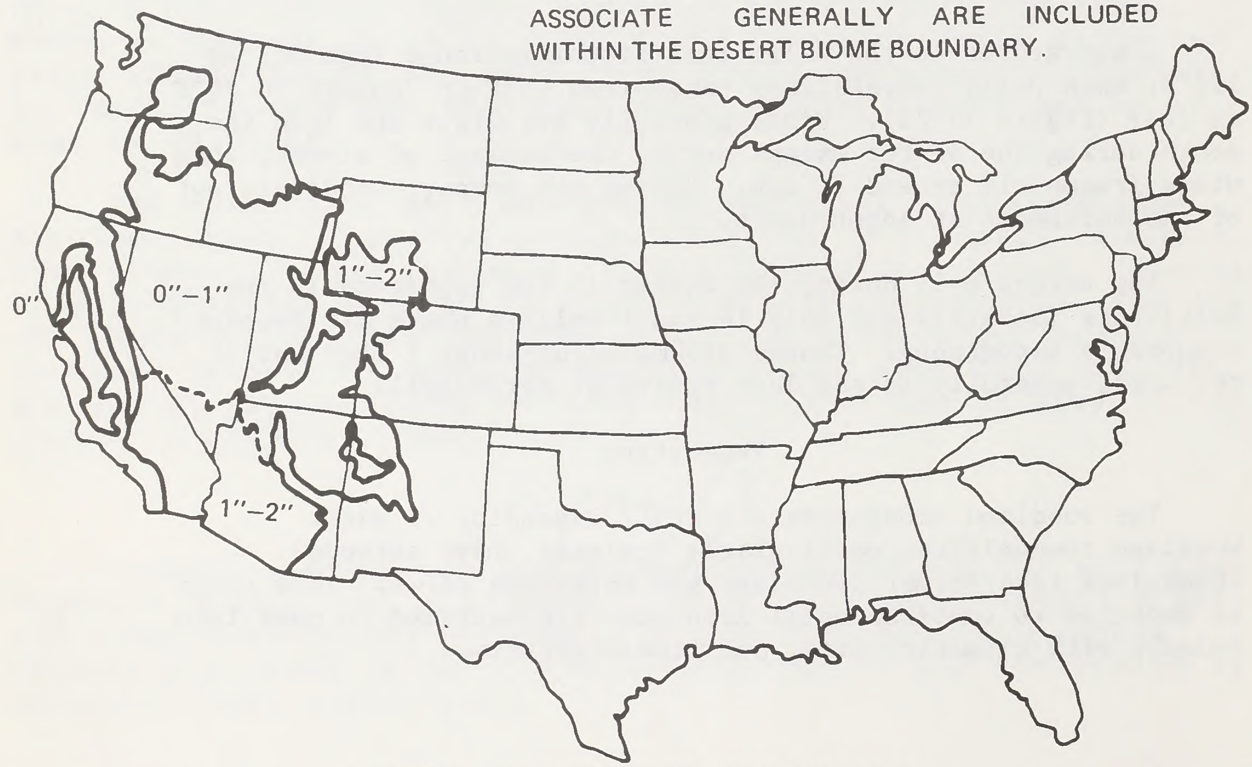
Vegetation

The woodland ecosystems are still expanding in size. Woodland communities, particularly junipers, have extended themselves into former grassland and sagebrush sites. This trend is expected to continue until land uses are modified to come into balance with climatic, site, and biotic factors.



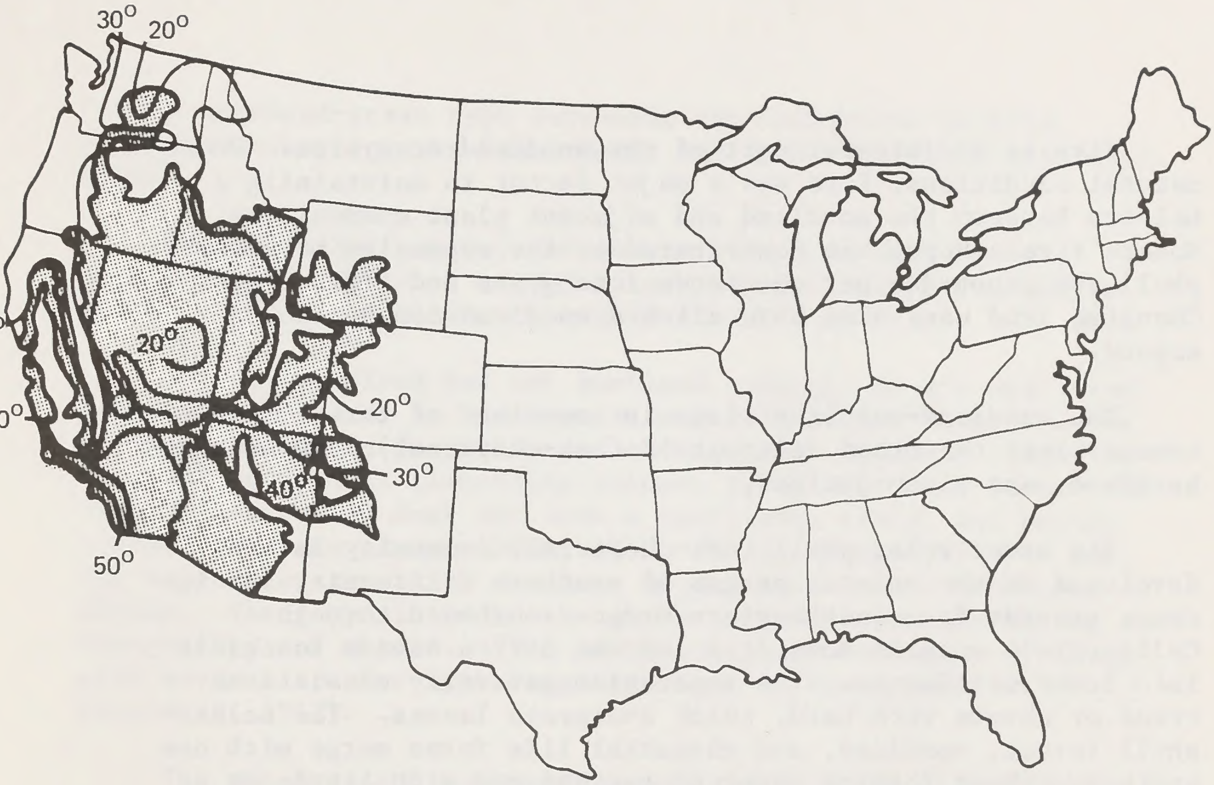
MONTHLY PRECIPITATION (INCHES)–JANUARY

THE OAK WOODLAND–BUSHLAND AND JUNIPER ASSOCIATE GENERALLY ARE INCLUDED WITHIN THE DESERT BIOME BOUNDARY.



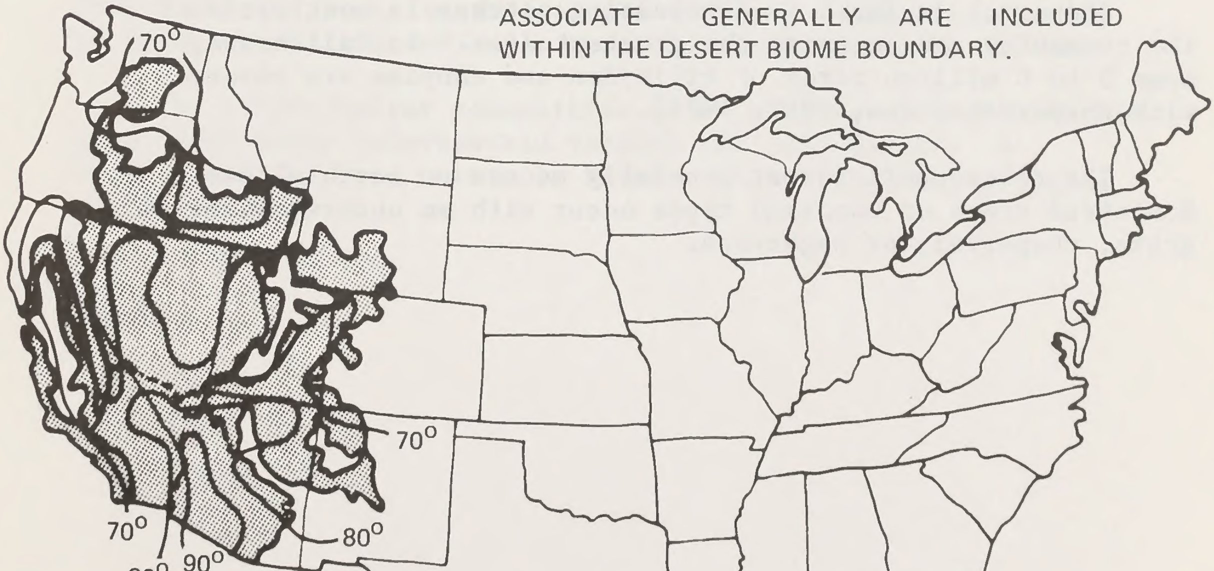
MONTHLY PRECIPITATION (INCHES)–JULY

Figure II-21 Average January and July precipitation in woodland-bushland communities



AVERAGE DAILY TEMPERATURE (0°F)—JANUARY

THE OAK WOODLAND—BUSHLAND AND JUNIPER ASSOCIATE GENERALLY ARE INCLUDED WITHIN THE DESERT BIOME BOUNDARY.



AVERAGE DAILY TEMPERATURE (0°F)—JULY

Figure II- 22 Average daily temperatures in woodland-bushland communities in January and July

Fire is an integral part of the woodland ecosystem. Under natural conditions, fire was a major factor in maintaining a balance between the woodland and adjacent plant communities. Modern fire control has contributed to the expansion of sclerophyll and pinon-juniper woodlands into grass and brush types. Changing land uses also have allowed woodland communities to expand.

The woodland-bushland biome is comprised of three broad communities; the broad sclerophyll (oak-chaparral); oak woodland bushland; and pinon-juniper.

The broad sclerophyll (oak-chaparral) community is best developed on the coastal ranges of southern California, but its range extends from southwestern Oregon southward through California's coastal mountains and the Sierra Nevada foothills into lower California. The vegetation generally consists of trees or shrubs with hard, thick evergreen leaves. The sclerophyll forest, woodland, and chaparral life forms merge with one another without forming distinct regions and with little or no plant succession relationship.

Chaparral is found in alternating patches in most parts of the community and occupies the greatest area. In California, some 5 to 6 million acres of hillsides and canyons are covered with chaparral (Odum, 1959, 1971).

The sclerophyll forest generally occurs on north slopes. Scattered trees or woodland types occur with an understory of grass, chaparral, or sagebrush.

A woodland-grass type surrounds the California prairie, extends north along the Coast Range and occurs in other scattered areas.

The chaparral consists of shrubs that form dense canopy thickets with little or no understory vegetation. It occurs on steep, loosely consolidated, highly erodible soils.

The oak woodland and oak bushland communities are scattered and generally occur as ecotones between the desert biome and the the Rocky Mountain foothills and the interior mountain ranges in Utah and Arizona at elevations between 5,000 and 8,000 feet. The vegetation usually does not form a continuous cover, but occurs instead in dense clumps (Odum, 1959, 1971). In addition to oak, the vegetation generally consists of many species of deciduous shrubs. The composition of the shrubs depends upon elevation, topography, and aspect. "The number of plant dominants is large with several species appearing regularly in each community" (Shelford, 1963).

The oak woodland community occurs in southern Arizona and New Mexico. Oak, juniper, small trees, undershrubs, and grasses are interspersed in the community. Understory vegetation ranges from cacti and yucca to grasses and shrubs. Topography usually is steep to rolling and soils generally are subject to erosion.

The pinon-juniper communities cover an area of approximately 60 million acres interspersed through the cold desert. A majority of the type occurs in Nevada, Utah, Colorado, Arizona, and New Mexico.

Pinon-juniper generally occurs at elevations between 5,000 and 7,000 feet. Stand density varies from a very few trees per acre to 600 or more per acre. An open stand is typical, but dense stands are not uncommon. Stands often thicken progressively from scattered trees at lower elevations to maximum densities just before the vegetation changes to timber or mountain shrub types. The lower, sparse stands are frequently developed on sagebrush or desert grass sites. Since junipers are more drought resistant, they are commonly found at elevations 500 feet lower than pinon. Broad areas with savannah characteristics occur in New Mexico and Arizona; the understory is comprised of mixed desert grasses and shrubs.

The herbaceous undercover varies inversely with the tree and shrub density. However, studies in Arizona indicated that shrubs may increase with the number of trees until a tree density of 50 percent is reached.

The shrub undercover decreases sharply where tree canopy exceeds 60-percent ground cover (U.S. Department of Agriculture, 1964).

A large number of plants in this biome have been designated as endangered. Some examples are: angelica (Angelica scabrida); locoweed (Astragalus Calycosus var. monophyllidiu); and indian buckwheat (Eriogonum cronquistii) Federal Register, July 1975).

Animal Life

Terrestrial Wildlife

Few animals are restricted to the pinon-juniper woodland. Birds such as the pinon jay and the gray flycatcher are characteristic species of this biome. Juncos are general inhabitants during the winter months. In the Kaibab-Zion area of southern Utah and northern Arizona, the mule deer is dominant. The mountain lion, coyote, and bobcat are the principal predators. The desert woodrat and the rock ground squirrel are characteristic residents. The nocturnal pinon mouse is perhaps the most abundant mammal found throughout the woodland. The cliff chipmunk, blacktailed jackrabbit, and mountain cottontail are of common occurrence. Nesting birds include the golden eagle, red-tailed hawk, and scrub jay.

The number of reptiles in the pinon-juniper is limited; they are most common at lowest elevations. reptiles include the sagebrush swift, several lizards, and the rattlesnake and kingsnake.

More mammals occur in the oak woodland of southern Arizona and New Mexico than in the pinon-juniper type. They include the ringtail, whitetail deer, mule deer, peccary, coati, and fox squirrel. Birds common to the biome include scaled quail, Mearns quail, turkey, and mourning dove. Forty-two permanent resident birds, at least 16 species of lizards, and as many snakes have been listed.

In the oak bushland, mule deer and the coyote are prominent. The longtail weasel and spotted and striped skunks are common. Hibernating mammals include the jumping mouse, marmot and Uinta ground squirrel, and golden-mantled squirrel. Robins, jays, and chickadees are common. Large, mixed flocks of birds winter in canyon bottoms or other sheltered locations. Of 11 reptiles in the community, only the rubber boa appears to belong primarily to the bushland.

Several subspecies of mule deer range throughout the broad sclerophyll community. Typical mammals include the mountain lion, bobcat, coyote, gray fox, wood rat, skunk, and brush rabbit. The Merriam chipmunk, California mouse, and kangaroo rat are confined to chaparral. Many small birds and lizards live in the community and amphibians include the tree frog and certain salamanders. (Odum, 1945; U.S. Department of the Interior, 1974; U.S. Department of Commerce, 1947, 1965, and 1970; Everhart and Seamon, 1971.)

Aquatic Wildlife

Aquatic wildlife forms are characterized by cold and warm water fish species. A variety of aquatic environments exist in small, sometimes intermittent streams, upper reaches of larger rivers, impoundments, and some natural lakes.

Waters are moderately rich in nutrients and microorganisms; water quality may be fair to good. Some streams may carry heavy silt at times in brushland areas; the better quality and more stable waters are located in wooded areas.

Representative fish are trout, white fish, catfish, suckers, carp, squawfish, shiners, minnows, dace, chubs, sculpins, sunfish, perches, basses, and pikes.

Endangered Wildlife

Endangered species of wildlife recognized in the woodland-bushland biome include: Utah prairie dog (Cyonomys parvidens); San Joaquin kit fox (Vulpes macrotis mutica); California condor (Gymnogyps californianus); American peregrine falcon (Falco peregrinus anatum); blunt-nosed leopard lizard (Crotophytus silus); Colorado river squawfish (Ptychocheilus lucius); humpback chub (Gila cupha); and woundfin (Plagopterus argentissimus) (Federal Register, Sept. 1975).

Domestic Livestock

The pinon-juniper type serves as spring and fall range for both sheep and cattle and as summer range for cattle only, in some areas. Some winter sheep grazing occurs in the southern half as well as some yearlong cattle grazing. Horse grazing is minor, although portions of some wild horse areas are located in this biome.

Most of the forage species in the broad sclerophyll community are winter annuals. Therefore, most grazing occurs during the winter and early spring.

The number of cattle in the biome has been increasing and the number of sheep has been declining for several years. The number of domestic horses has leveled off after declining sharply.

Most ranches are cow-calf operations. Sheep ranches place emphasis on grass-fat lambs. In the broad sclerophyll community, many cattle ranches run steers or yearlings because of the seasonal nature of the forage.

Wild Horse and Burros

The range of wild horses throughout the desert biome includes associated habitat inside the pinon-juniper regions of the woodland-bushland biome. Reports show that less than 100 burros graze in this biome.

Human Life

The population and economic aspects of this biome are dominated by the California coastal range, from San Francisco to San Diego. Over 46 percent of the total population of the 11 Western States reside in this region, mostly in urbanized areas. Population density of the central coastal area averages 310 persons per square mile, while the southern coastal area averages 762 persons per square mile. Incomes are relatively high, 12 percent above the western average, and the percentage of families below poverty levels is lower.

Only 1 or 2 percent of total employment is in agriculture. The livestock-related economy is minimal. The region is estimated to import more than four times the amount of livestock produced within the region.

ROLE OF FIRE

Philpot (1973) used chamise, a major chaparral component, as a model of the role of fire in the chaparral type. Chamise has many characteristics that make it highly flammable, including a high heat and crude fat content, low moisture content during drought, a majority of its fuel surface area in smaller size classes, and horizontal and vertical continuity (Countryman and Philpot, 1970). The scenario following fire begins when chamise sprouts from a root crown after stems and foliage have been killed by fire. Some new chamise plants are established when heat-treated seeds germinate. Due to volatilization of phytotoxic compounds in the soil by fire, several species of fire annuals (grasses and forbs) also germinate after the fire (Muller et al., 1968). The annuals occupy the site for about 5 to 7 years until phytotoxic compounds produced by chamise suppress them. Approximately 10 years after the fire, the stand is nearly pure chamise again. As the stand matures, the quantity of dead fuel increases with age. The longer that fire is deferred in this fire type, the greater will be the eventual fire intensities and fire sizes. A similar fire cycle has been described for manzanita (Vogl and Schorr, 1972).

Leopold (1924) described several shrubs, including juniper, mountain mahogany, oaks, and manzanita in the southern Arizona foothills. He considered the recurrence of fire as a major factor in maintaining open grasslands. Other authors have reported significant increases in juniper in New Mexico, Texas, Utah, Idaho, and Oregon. Several reasons have been advanced for encroachment by juniper; the major ones are grazing pressure, climatic changes, and fire.

Several authors have reported the successional stages in pinon-juniper woodland after fire (Erdman, 1970; Barney and Frischknecht, 1974). Successional trends are similar for Arizona, Colorado, and Utah. Annual plants form the initial stage after fire, reaching maximum development in the first 3 to 4 years. The annual stage is generally replaced by a perennial grass-forb stage by the fifth or sixth year.

A shrub stage may follow the annual stage if shrubs are dominant to the exclusion of perennial grasses prior to the fire. If a perennial grass stand develops first, it is usually followed by sagebrush and then juniper. If the shrub stage develops, it may be converted to a grassland stage by a second fire. When protected from recurring fires, both the shrub and grassland stages will be reinvaded by trees (the pinon-juniper climax).

Human Interest Values

Land Uses

Rough and steep topography limit agriculture activities in most areas to livestock grazing. Minor portions of the biome are irrigated.

Big game and upland game birds provide hunting opportunities in most parts of the biome. Areas near cities and towns are used extensively for outdoor recreation; recreation use probably will increase in the future.

Many areas in the biome, such as the California "mother lode" country, were mined extensively for minerals over a hundred years ago. Most of the mining in that area is now restricted to individual part-time efforts. Underground mining of coal occurs in Utah and Colorado. Open-pit coal mining is increasing. Uranium is mined underground. Areas in Colorado, Utah, and New Mexico produce oil and gas, and the potential for discovery of additional production areas appears to be relatively high. The western side of the San Joaquin Valley of California also has oil-and gas bearing formations and a number of producing wells. Oil shale outcrops in large areas in Colorado, Wyoming, and Utah. Experimental work has been done over the past several years in the recovery of petroleum from some of these deposits. The BLM has recently issued leases on some of the oil shale in Colorado. Potentially, land uses could be altered drastically on oil shale areas if commercial production occurs.

The biome contains extensive roadless or undeveloped areas with primitive qualities. Some streams in these areas may meet criteria for wild rivers; a number are now under study. The California oak-chaparral tends to be more developed and has fewer areas with primitive or semiprimitive qualities.

Woodlands in the biome provide a small, but locally important, source of cordwood and fenceposts. Pinon-pine nuts are harvested by Indians and others.

Small, isolated ranching or mining towns are scattered throughout the area. Suburban expansion is occurring in the biome in California and in the Salt Lake City area.

Aesthetics

The woodland-bushland visual environment is one that varies greatly. It ranges from a semi-arid to a wooded foothills landscape.

Since valley bottoms in the West are also principal travel routes, much of the woodland-bushland type is exposed to view of the traveling public. In some areas, this view is from a considerable distance. In others, it is directly adjacent to the travel route.

Landform of the woodland-bushland communities varies from relatively flat valley bottoms through the low-rolling foothills to deep-cut canyons and high mesas. Most typical of these would be the rolling foothill area.

Texture varies as the density of the stands vary, from a continuous dense canopy to an open, scattered random pattern.

Color varies almost as much as landform and texture. Where there is a fairly continuous canopy, the gray-green of the vegetation is predominant. As the stands thin, color of the soil or rocks become dominant. During favorable moisture periods, vast arrays of brightly colored flowers add a most aesthetically pleasing aspect to this biome. This often occurs after a fire.

Lines are evident only where there is an abrupt change in the vegetation type or where there has been some disruption of the vegetation, i.e., roads, powerlines, chaining, etc. Scale is more easily defined and much more obvious in the woodlands than in the grasslands or desert.

Geological

Most geological features of interest are similar to those found at similar elevations in the surrounding desert or grassland areas which have been previously discussed. For example, the woodland-bushlands may cover the tops of high mesas that are an integral part of the dramatically eroded areas on their flanks. In the California foothill woodland areas, there are numerous faults. Large faults, such as the San Andreas fault passing through both prairie and woodlands, exhibit visible displacement.

Archeological

Prehistoric peoples who used the juniper associate and oak woodlands were, for the most part, the same types who inhabited the hot and cold desert. Different activities tended to take place in the woodland-bushland biome such as hunting or gathering of wild nuts and seeds, but one also finds agricultural areas cleared in the juniper areas so there is no clear-cut division of usage.

In the broad sclerohyll areas of southern Oregon and California are indications of the same prehistoric peoples as in the California and Palouses prairie grasslands--an Old Cordilleran Tradition base that developed into an Archaic Tradition that continued to current times.

Historical

Historically, the woodland-bushlands were probably among the last areas to be settled because of the difficulty of converting them to agriculture. Heavy brush and the lack of water made the biome less valuable for agriculture, and grazing was the predominant use in most cases. Consequently, most of the historic events that took place in the woodland-bushland tended to be associated with livestock trailing and Indian wars, rather than settlement oriented.

The broad sclerophyll community in California includes the "mother lode" country of the 1849 gold rush. The area is replete with old ghost towns, and remains of mining activities such as dredge piles and huge hydraulic cut banks.

Cultural

This biome has cultural values similar to those of the desert. Of more unique significance, brushlands and wooded foothills of the southwestern portion of California lie along the route of the Spanish Roman Catholic missionaries of the 18th century. Many missions have been restored along El Camino Real, while other sites remain as interesting ruins of more historical than cultural or religious significance.

CONIFEROUS FOREST BIOME

In general, conifer forests of the West occupy mountains and the higher plateaus, and the regions of relatively abundant moisture of the Pacific coast and Alaska. Three sub-biomes are recognized: Montane, Northwest Coastal, and Taiga. The location of these biomes are shown in figures II-23 and II-24 and their aspect is shown in figures II-25, II-26,and II-27.

Topgraphy

The Cascade and Siskiyou Mountains, Coast Range, and the Sierra Nevada are moderately to steeply sloping with relief from base of peak varying from 1,000 feet to over 3,000 feet. Volcanic cones are distinctive features of the Cascade Mountains. On the Columbia Plateau, the topography is moderate to gentle. In the northern Rockies and most of the southern Rockies, the mountains are moderately to steeply sloping, with relief in some areas exceeding 3,000 feet.

Along the southern and southeastern coast of Alaska, the topography of the forest area varies from low mountains to high mountains, with steep slopes, and relief varies from 1,000 feet to over 3,000 fet.

In interior Alaska, the commerical forests are located in narrow bands along the river drainages and on the flat plains. The noncommerical forests are found on hills and mountains with relief ranging from 500 to 3,000 feet.

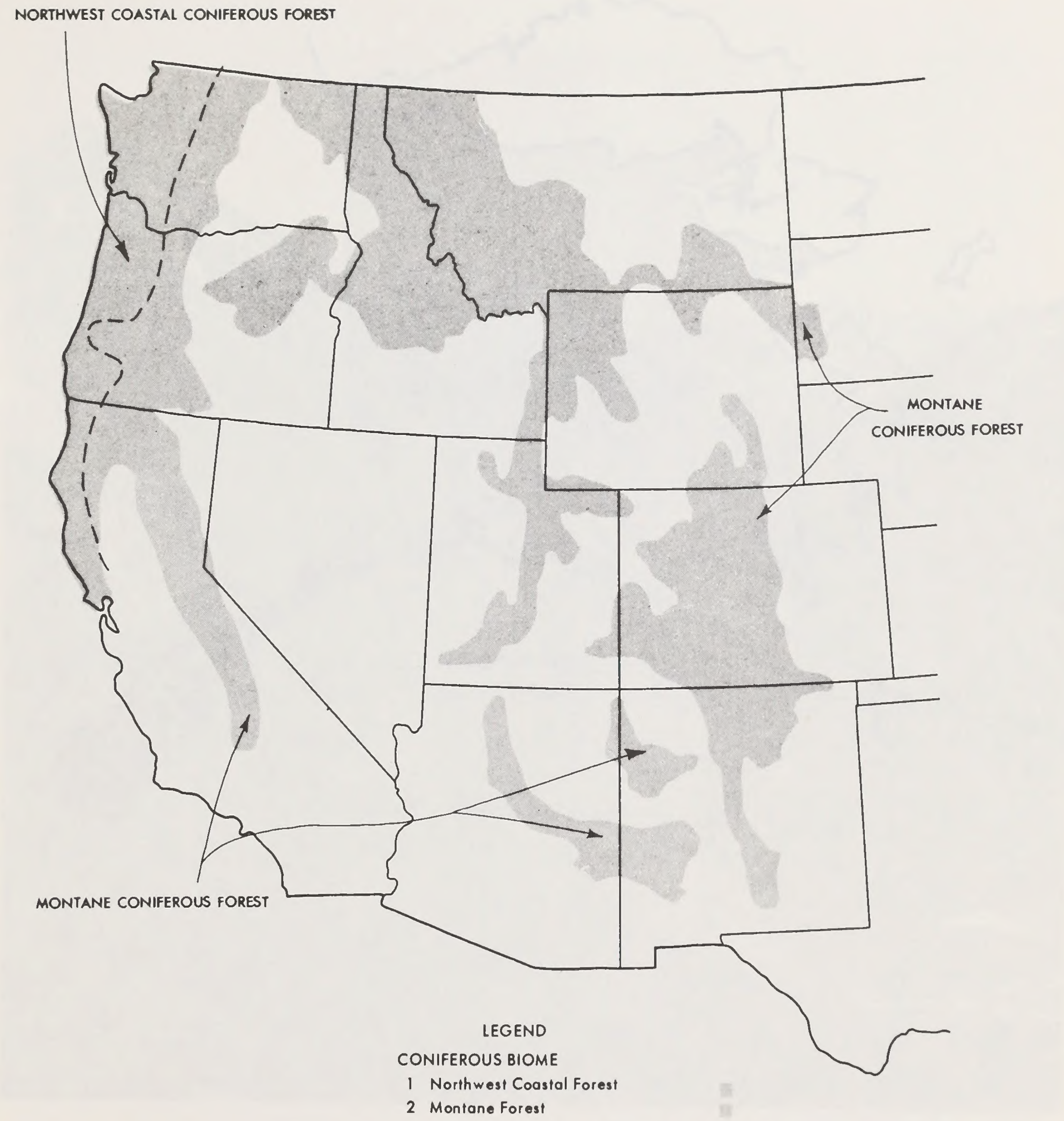


Figure II- 23

CONIFEROUS BIOME IN THE
WESTERN UNITED STATES.

Figure II-24. Coniferous Forest Biome in Alaska

Figure II-25. The Montane Coniferous Forest

Figure II-26. The Northwest Coastal Coniferous Forest

Bureau of Land Managemement Photo

Figure II-27. The Taiga Coniferous Forest

Soils

Soils in the coniferous forest biome range from the Inceptisols in cold wet climates to the Mollisols in warm dry climates.

Inceptisols and Ultisols generally occur in the higher elevations and in areas receiving considerable precipitation. Ultisols have clay-enriched subsoils and are acid in nature. Characteristics of the Inceptisols vary greatly. Inceptisols and Ultisols occur in northeastern California, western Oregon and Washington, and from the Canadian border in northern Idaho and northwestern Montana to central Idaho. A few areas of Spodosols are intermingled with the Inceptisols and Ultisols. Inceptisols are found throughout Alaska where mineral soils occur.

Alfisols occur in areas receiving less rainfall than areas in which Ultisols have formed and therefore are more basic in nature than in the latter. Alfisols have a clay-enriched subsoil and a gray to brown surface soil. Large areas of Alfisols are located on the east and west sides of the Sacramento Valley in California and on the east front of the Rocky Mountains in Montana, Wyoming, and Colorado.

Mollisols are basic soils which are organically rich and dark colored. Mollisols are located in the southern Rocky Mountains in Utah and Arizona.

Entisols are young soils lacking distinctive subsoil horizons. They occur on recent deposits of alluvium, on very steep areas having soil creep, and on recently stabilized sand dunes. These soils occur in western Colorado, northwestern New Mexico, and central Utah.

Aridisols are generally associated with the desert. However, Aridisols support coniferous forest in parts of New Mexico and Arizona.

Permafrost conditions occcur discontinuously through portions of the taiga forest of Interior Alaska. Soils in the valleys and the lower mountain slopes are covered with a thin to thick blanket of vegetative material that acts as an insulating mat. In most of Interior Alaska, this mat protects and stabilizes the underlying permafrost. When the vegetative cover is disturbed or removed, the permafrost is exposed and melts during the summer. (Soil stability classes, the soil orders and series, and major soil characteristics are described in appendices I, J, and K.)

Minerals

Mining, mineral processing, and refining have significantly affected the human environment in and near many local communities. Copper, coal, gold, silver, lead, zinc, molybdenum, and phosphate are the principal products. In the early history of mining in these and many other unnamed localities, mining was generally carried on by underground methods, whereas today in some of the above localities, mining is being done by open-pit methods. These changes have aggravated waste and tailings disposal problems.

Water

The water resources of the coniferous forests provide for most of the water needs for the Western United States. Major rivers and streams flow from the forest into the grassland, desert, and woodland-bushland biomes. Most streams of the coniferous forest are perennial, although some may be intermittent in regions where extended dry periods occur during certain seasons. Natural lakes are an important part of the surface water resource of the coniferous forest biome.

Average annual runoff from the coniferous forest ranges from about 5 inches in the southern Rocky Mountains to more than 150 inches in parts of northwest Washington and southeastern Alaska. Most of the runoff occurs during the spring and early summer months in the higher elevations and in central Alaska where precipitation falls mostly as snow. However, in the lower coastal mountains of northern California, Oregon, Washington, and southeastern Alaska, where precipitation occurs during the winter predominantly as rainfall, most of the runoff occurs from November through March.

The quality of most surface waters in the coniferous forest is good to excellent. Average dissolved solids content generally is less than 100 ppm. The suspended sediment concentrations in coniferous forest streams are generally less than 280 ppm.

Climate

Moist Pacific air moving in a west to east path results in high rainfall in mountain ranges along the northwest coast from Alaska to California. After the dry season reaches its climax in July and August, the rainy season comes on gradually and reaches its peak in December. Average annual precipitation ranges from 30 to 40 inches in the San Francisco area, 60 to 140 inches in the Olympic Mountains of Washington, to 80 to 150 inches in the south-central coast of Alaska. Temperatures range from a low of -15°F along the Alaska coast to 30°F at San Francisco; high temperatures can reach into the 90's throughout the area. Mean daily temperatures range from 20°F to 35°F in January to 50°F to 60°F during July. During the winter, the wind sometimes attains hurricane force along the ocean coast. Northerly winds prevail in summer months--especially in the daytime. Thunderstorms are infrequent and usually weak along the western part of the area.

The climate of the taiga forest is typified by severe winters and warm summers. Average annual precipitation ranges from 7 inches in the upper Yukon to 16 inches in the Matanuska Valley (figure II-28). Winter temperatures range from -75°F along the basin of the Yukon to -35°F in the Matanuska Valley. Summer maximums are 90°F to 100°F. The mean daily temperatures vary from -15°F in January to 50°F in July (figure II-29). Winds generally are out of the east during the winter months at about 5 mph. During the short summer season, winds out of the west bring moist maritime air in from the Bering Sea. During the summer, thunderstorms occur at an average of 5 to 10 days each year. The daily hours of sunshine in June in the interior of Alaska range from 16 hours in the lower latitudes to 24 hours in the northern latitudes. There are nearly as many cloudy days as clear days in the course of a year, and this reduces the incoming solar radiation during summer months.

(1) MONTHLY PRECIPITATION (INCHES)—JANUARY
[3] MONTHLY PRECIPITATION (INCHES)—JULY

Figure II-28 . **Average January and July precipitation in the coniferous forest biome — Alaska**

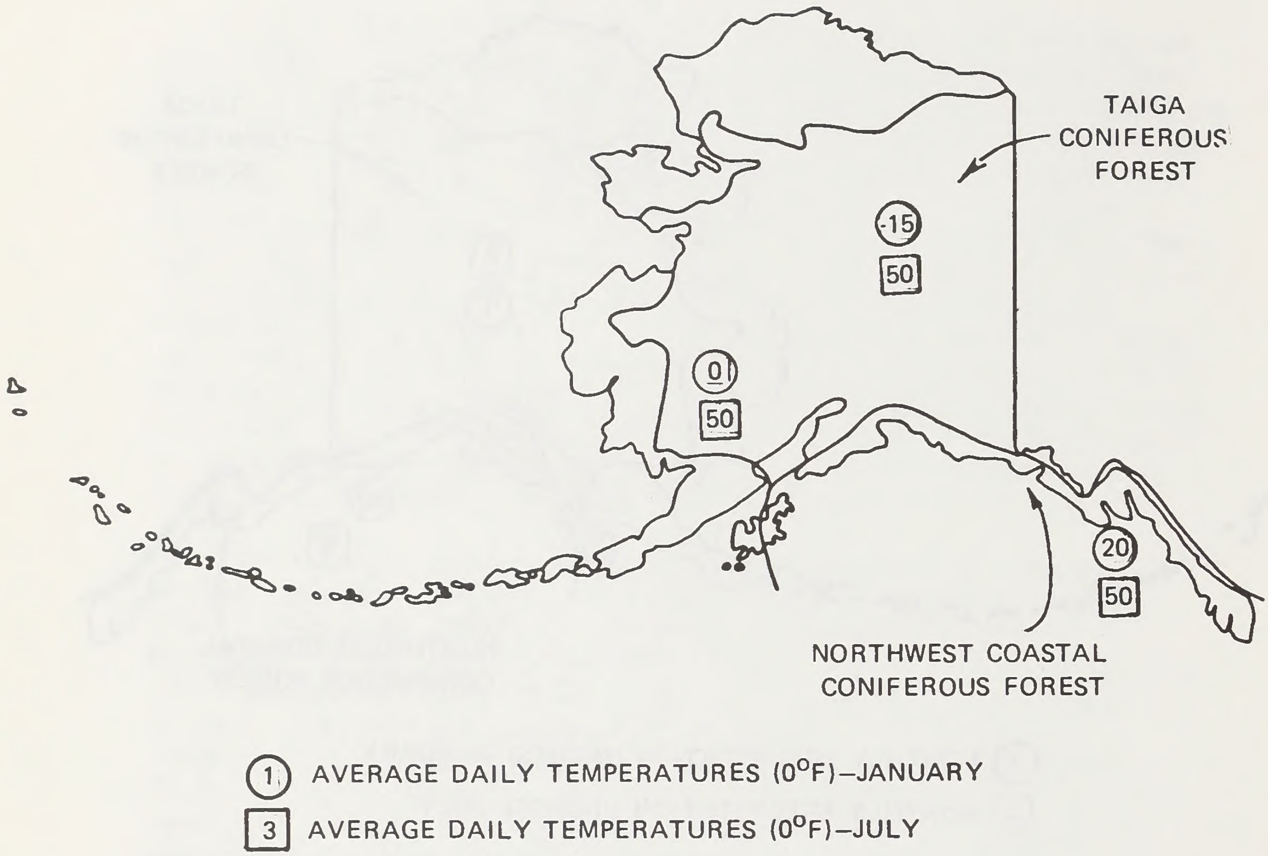


Figure II-29. Average daily temperatures in the coniferous forest biome in January and July — Alaska

The climate in the montane coniferous forest is directly related to elevation; the higher the elevation, the colder and wetter the climate. Precipitation at the lower levels generally averages about 16 inches a year. The higher elevation Sierra Nevada receives 50 inches, the Cascades 90 inches, and the Rockies 30 inches. Average January precipitation varies from 8 inches along the Sierras and Cascades to 1 to 3 inches in the Rockies. Average July precipitation ranges from 1 inch or less along the Sierra Nevada and Cascades to 2 to 3 inches in the Rockies (figure II-30). Average daily minimum temperatures during January range from 20°F at the lower elevations to 0°F at the higher elevations (figure II-31). Maximum temperatures during July average 85°F at lower elevations to 70°F at higher elevations. The mean daily temperatures average about 10 degrees warmer during January and 10 degrees colder during July. Topography and convective activity--especially during the summer months--affect wind directions and velocities. At the mountain summits, winds generally are from the west and frequently are very strong in the winter and spring. Thunderstorms occur frequently in the montane coniferous forest. An average of 50°F to 70°F occurs in the forested areas of Colorado and New Mexico each year.

Vegetation

The dominant flora in this biome are coniferous trees, especially spruces, firs, and pines. The conifers form a relatively continuous canopy over the forest floor.

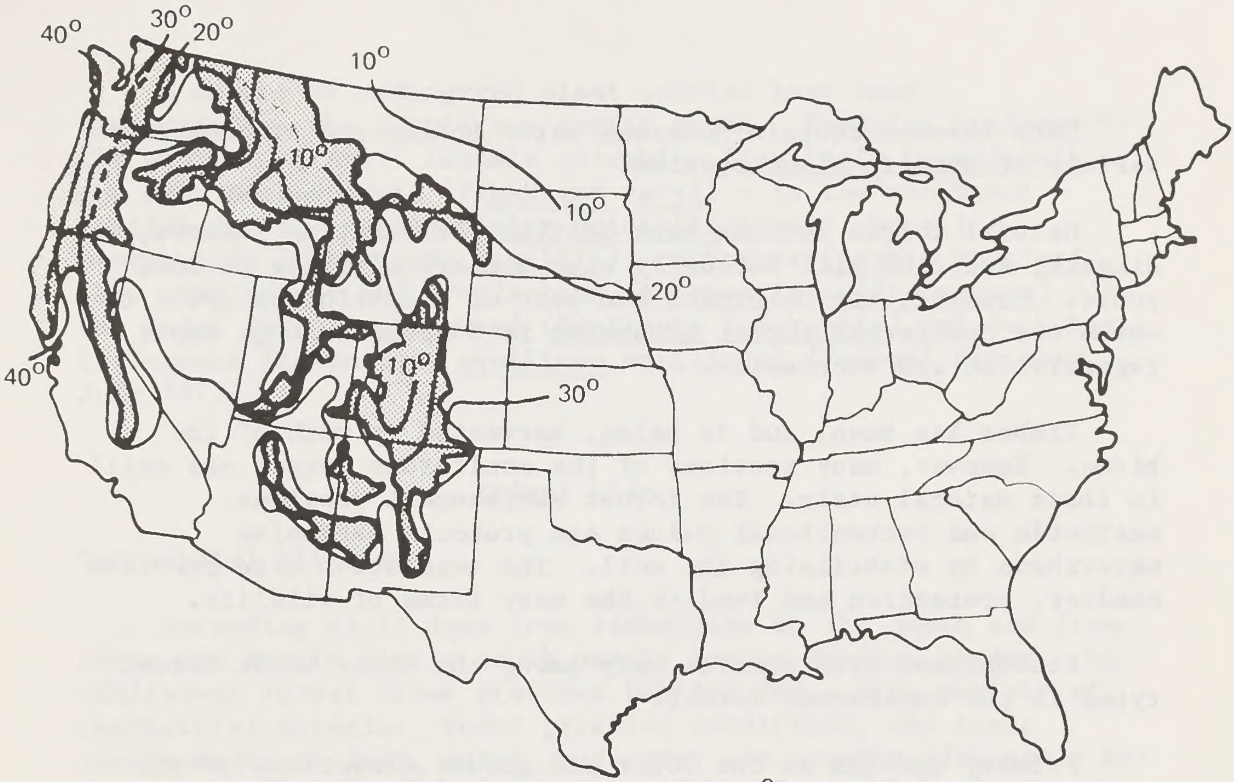
Productivity varies from the generally fast-growing forest of the northwest coastal sub-biome to the less productive forests of the montane and taiga.

The compostition of the forest vegetation is influenced to a large extent by elevation. Elevational differences lead to the development of four basic vegetational zones in many mountainous areas. Proceeding upward from the lowlands, the zones are the woodlands, forest, subalpine forest, and alpine meadows.

MONTHLY PRECIPITATION (INCHES)–JANUARY

MONTHLY PRECIPITATION (INCHES)–JULY

Figure II-30.
Average January and July precipitation in the coniferous forest biome–conterminous United States



AVERAGE DAILY TEMPERATURES (0°F)—JANUARY

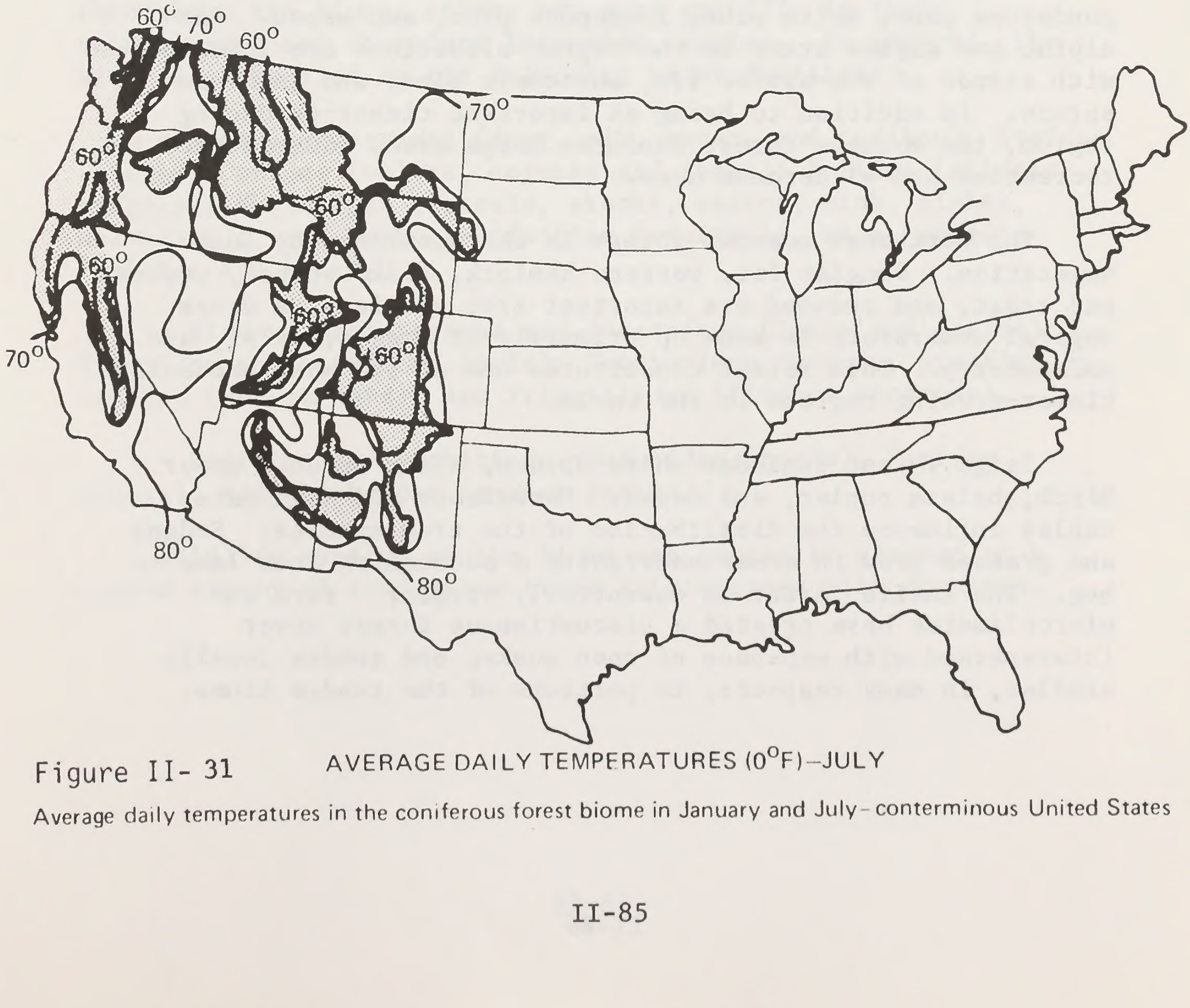


Figure II- 31 AVERAGE DAILY TEMPERATURES (0°F)—JULY

Average daily temperatures in the coniferous forest biome in January and July—conterminous United States

Many forests contain numerous water bodies and streams and a variety of aquatic plant species.

Natural forces such as bark beetles, defoliating insects, disease, and fire kill unusually high numbers of trees in some years. However, the outbreaks are part of a continuous cycle to which the coniferous forest ecosystem is adapted through rapid regeneration and succession.

Timber has been, and is being, harvested in much of the biome. However, many sections of the coniferous forest are still in their natural state. The forest environment provides aesthetic and recreational values and protects extensive watersheds by stabilizing the soil. The vegetation also provides shelter, protection and food to the many forms of wildlife.

Predominant tree species vary among the three basic forest types in the coniferous forest.

Primary species in the lower and middle elevations of the montane forest are Douglas fir, Englemann spruce, western larch, ponderosa pine, white pine, lodgepole pine, and aspen. Sub-alpine and alpine areas in the higher elevations are interspersed with stands of sub-alpine fir, whitebark pine, and Engelmann spruce. In addition to being an important timber-producing region, the montane forest includes large areas administered for recreation and wilderness uses.

The northwest coastal forest is characterized by lush vegetation. Douglas fir, western hemlock, Sitka spruce, western red cedar, and redwood are important tree species. A dense vegetal understory is made up primarily of mosses, salal, and salmonberry. This forest constitutes one of the most productive timber-growing regions in the world.

Taiga forest includes white spruce, black spruce, paper birch, balsam poplar, and aspen. Permafrost and high water tables influence the distribution of the tree species. Sedges and grasses grow in areas undergoing a succession from lake to bog. The entire forest is essentially virgin. Fire and microclimates have created a discontinuous forest cover interspersed with expanses of open muskeg and tundra locally similar, in many respects, to portions of the tundra biome.

A number of endangered plant species have been designated in the coniferous forest biome. Examples include--in the montane forest: Laramie columbine (Aquileqia Laramiensis) and cary beardstongue (Penstemon caryi) - in the northwest coastal forest: aster (Aster brickellioides); Howell's scorzonella (Microseris howellii); rockcress (Arabis koehleri var. stipitata); and everlasting (Antenmaria suffrutescens) - in the taiga forest: Locoweed (Oxytropis Kobukensis) and buckwheat (Erioqonum flavum var. aquilinum aquilinum) (Federal Register, July 1975).

Animal Life

Terrestrial Wildlife

Extending as it does from timberline to the ocean and from above the Arctic Circle south nearly to the Mexican border, the coniferous forest biome provides habitat for a wide variety of terrestrial animals. Under pristine conditions, the basic requirements of food, water, and cover are usually adequately met for most indigenous species. Some adaptable species are found throughout the biome; others are more specific in their requirements and therefore less wide ranging. In general, the biome is inhabited by the following major families:

- Mammals--Cervidae (deer, elk, moose, and caribou); Ursidae (bears); Canidae (wolves, coyotes and foxes); Felidae (wildcats, cougars); Mustelidae (weasels, skunks, marten, mink, fisher, wolverine); and various Rodentiae (squirrels, mice, shrews, rabbits, and hares.)

- Birds-- Accipitrinae and Buteoninae (hawks and eagles); Tytonidae and Strigidae (owls); Tetraonidae (grouse, ptarmigan); Picidae (woodpeckers); and Fringillidae (finches,sparrows).

- Reptiles and amphibians--Bufonidae (toads), Ranidae (frogs), and Colubridae (garter snakes).

Wildlife typical of the biome are generally adapted to a closed canopy of coniferous trees interspersed with openings.

Some species, particularly the herbivores, respond to the edge effect created by forest meadows, logging, or fires that favor development of an understory of nutritious vegetation. Other species, including the raptors and larger predators, may respond adversely to loss of the forest overstory. Most forest wildlife can adapt to certain habitat changes, but extensive land management activities can be detrimental to many species, especially when accompanied by vehicles and people. Many fur-bearers and birds in this biome require a semiaquatic habitat, and streams, ponds, and lakes increase the variety of wildlife.

The animals of the taiga sub-biome can tolerate the cold of subarctic and arctic winters. Invertebrates and many of the vertebrates are dormant during the winter months and active during the warm season, in an annual cycle that brings a spring influx of migratory birds and speeds their departure in autumn. The following animals are typical of the taiga:

- Mammals--Barren ground caribou, moose, grizzly bear, gray wolf, lynx, wolverine, marten, porcupine, snowshoe hare.

- Birds--Gyrfalcon, snowy owl, Arctic horned owl, spruce grouse, ruffed grouse, ptarmigan, Arctic three-toed woodpecker.

- Reptiles and amphibians--Tree frog.

Dall sheep and caribou are found principally in the partially timbered mountains of this sub-biome. The herbivores of the taiga are principally browsers, but lichens and sedges are important items in the diet of caribou and, to a lesser extent, sheep. Predator-prey relationships are pronounced, with lynx and owl populations dependent upon the fluctuating numbers of the varying hare, and wolves preying principally on the larger herbivores.

A much greater variety of habitat exists in the montane coniferous forest sub-biome than in the taiga or northwest coastal sub-biomes. The variety of vegetative types favors a high degree of use by numerous species; some 56 species of birds have been recorded as breeding in the central Rocky Mountains. The following are representative wildlife:

- Mammals--Elk, mule deer, whitetail deer, Bighorn sheep, mountain goat, black bear, cougar, coyote, fisher, pika, cottontail rabbit, snowshoe hare, red squirrel, and various mice.

-Birds--Golden eagle, screech owl, gray-crowned rosey finch, northern three-toed woodpecker, ruffed grouse, American magpie, Clarks nutcracker, Canada jay.

- Amphibians and reptiles--Pacific tree frog, California mountain kingsnake.

The southwestern Oregon-northern California montane sub-biome area host the ringtail and chickaree in naturally limited environments. The same area may support blacktail deer concentrations rather than the representative mule deer populations.

Some northern Rocky Mountain habitats are utilized by grizzly bear and woodland caribou (both rare), moose, hoary marmot, and wolverine. The open forest in the southern part of the montane sub-biome and at the lower elevations are inhabited by mammals, birds, and reptiles which prefer drier sites; typical are the ringtail, tassel-eared squirrel, pinon jay, rattlesnake, and various lizards.

In much of the montane sub-biome, deep snows preclude yearlong residence, especially for large herbivores. In many areas, deer and elk annually migrate downward from high summer range to suitable winter cover and forage for survival.

Natural water supplies are usually ample for wildlife populations in the northwest coastal forest. Where the original forest canopy is intact, dense shade results in poorly developed understory vegetation and scant forage for herbivores. Contrary to some popular misconceptions, fires and logging have greatly improved wildlife habitats in much of the sub-biome by removing the closed forest overstory, thus promoting the rapid growth of nutritious forage plants. The principal wildlife species are related to those of the Rocky Mountains.

-Mammals--Elk, blacktail deer, black bear, cougar, lynx, bobcat, coyote, aplodontia, snowshoe hare, mink and various small rodents.

-Birds--Great horned owl, spotted owl, Cooper's hawk, bald eagle, sooty grouse, and band-tailed pigeon.

-Amphibians and reptiles--Pacific giant salamander, Puget Sound garter snake.

Other species inhabit specific vegetative zones in the sub-biome; e.g., the fisher and flammulated owl in silver fir and hemlock zones below timberline, the wolverine in the alpine zone above timberline, the grizzly bear in the Sitka spruce-hemlock zone of southeastern Alaska. The cougar, lynx and black bear are wilderness species that need the seclusion and escape cover provided by dense forests.

Aquatic Wildlife

The waters in most of the streams and rivers in the montane coniferous forest biome are usually of high quality and low temperatures. Aquatic ecosystems are diverse and complex. They usually contain a fair grade of aquatic food. High elevation streams support trout, whitefish, and sculpin. Lower streams support chub, carp, dace, suckers, and salmonids. Other common fish in the biome are black bass, sunfish, catfish, pike, and minnows.

West coast streams produce anadromous steelhead and five commercially important species of salmon: the chinook, sockeye, chum, pink, and coho. Migratory populations of coastal cutthroat trout are present in many coastal streams from California to Prince William Sound, Alaska. The anadromous fisheries are unique and directly dependent on the forest watershed.

Inland waters of the coniferous biome that do not empty directly into the sea are characterized by high quality, low temperatures, and a fair grade of aquatic food.

The taiga sub-biome provides aquatic ecosystems characterized by high quality water of low temperatures in lakes, ponds, and marshes in various stages of natural succession. The larger river systems support commercially important runs of Pacific salmon, among them the Bristol Bay sockeye salmon fishery. Sockeye and chum salmon are the most numerous anadromous species. Typical residents are arctic grayling, whitefish, sheefish, and lake trout.

Endangered Wildlife

Endangered species include the Columbia white-tailed deer (Odocoileus virginianus leucurus); American peregrine falcon (Falco pereqrinus anatum); greenback cutthroat trout (Salmo clarki stomias); Kendall Warm Springs dace (Rhinichthys osculus thermalis); Northern Rocky Mountain wolf (Canis lupus irremotus); and the grizzly bear (Ursus arctos horribilis) (Federal Register, Sept. 1975).

Domestic Livestock

Most domestic livestock grazing in the coniferous forest occurs on the mountain meadows interspersed as small islands throughout the biome and in open forest stands where forage species grow among scattered trees. Generally cattle graze in the lower elevations and most of the sheep in the higher elevations in the alpine zone.

Most livestock grazing occurs between June 15 and October 1. Some horses graze in the biome in connection with recreation activities. Although horse use is generally minor, it tends to concentrate adjacent to recreation, fishing and hunting areas in popular areas. Over the years, livestock use declined on the coniferous forests as portions were withdrawn from grazing for watershed protection purposes. This trend could continue as demand for water increases in the West.

Wild Horses and Burros

Some bands of wild horses in the desert biome will range into remote areas of the montane coniferous forest as part of their seasonal habitat. Because of the higher elevations in the coniferous biome, adverse winter climatic conditions restrict year-round use of the biome by wild horses except in those mountain areas where exposed south-facing slopes may afford marginal habitat.

Human Life

About 20 percent of the Western States' population resides in this biome, principally in the Pacific Nothwest. Population densities vary, as they do in the grassland biome. Unlike the grassland biome, the rural population has increased since 1960 instead of decreased, with the exception of the Idaho mountainous area. Except for the Pacific Northwest and the California portions of this biome, income levels are lower than average and the percent of families below poverty levels is higher, but differences are not as great as in the grassland biome.

The economies of this biome are heavily dependent on primary-type industries. In the Pacific Northwest and mountains of California and Idaho, the timber industry dominates the primary sector with agriculture second. In the mountainous areas of Arizona and Colorado, mining is the major primary industry very closely followed by agriculture. In Montana, Utah, and Wyoming, agriculture--principally livestock production--is at least of equal importance with mining and timber. Except for the Pacific Northwest, the percent of employment in agriculture is above the western average, but not nearly as high as in the grassland biome. Income derived from livestock production ranges from a low of two-tenths of 1 percent of total income in the Pacific Northwest, to about 6 percent of total income in the Idaho portion of the biome. The Public Lands supply 1,110,000 cattle AUM's and 250,000 sheep AUM's which represent about 6 percent of the total livestock feed consumed in the biome.

The Seattle and Portland metropolitan area are located in a broad valley extending from Puget Sound to central western Oregon. The valley contains the bulk of the intensive agricultural land in the region. Low cost hydroelectric power, abundant water resources, and deepwater ports have contributed to industrial growth in these urban areas.

Most communities in the montane coniferous forest are also small and serve the logging, ranching, or mining that may occur in the area. Recreation expenditures also play a significant role in community support throughout this biome.

Essentially uninhabited outside the Anchorage and Fairbanks urban areas, the vast region of central Alaska has a population density of only 0.5 persons per square mile. Scattered and remote white and native settlements are located along major river valleys and the limited road systems. In percentage terms, Alaska's rate of growth has been rapid in the past decade with a 33-percent increase in population between 1960 and 1970, for a total population of 300,000. Only about 30 percent live outside urban and suburban areas (U.S. Department of Commerce, 1972).

Native inhabitants of the sub-biome are of the Na-Dene Indian linguistic stock and are highly dependent on fish and wildlife for their livelihood (U.S. Department of the Interior, 1970). Summer employment fighting the numerous taiga wildfires is a source of income to the men. Some additional employment is available in the numerous small sawmills that operate part time in the Interior to provide logs and lumber for local use. This is not an important source of employment, however, compared to jobs in the fishing industry, general construction and road or pipeline construction.

The lack of adequate road transportation in this area of Alaska has limited development largely to those areas that are reachable by the few existing roads. Air travel is used extensively throughout the Interior. Consequently, much of the region remains wild, remote, and inaccessible and represents one of the largest remaining contiguous wilderness areas in the world.

THE ROLE OF FIRE

Fire is an important ecological factor in the biome, since it can alter a relatively stable habitat by removing the predominant forest cover and result in creating new biological communities. The increased diversity of plant species, higher protein content, and edge effect created by fire can improve the habitat for wildlife and fire is considered by many forest ecologists as necessary to perpetuate the lodgepole pine type in the montane forest. Favorable climatic conditions generally enhance rehabilitation and natural successional recovery in the northwest coastal, montane and taiga forest ecosystems.

Daubenmire and Daubenmire (1968) indicated that fire incidence in the northern Rocky Mountains stands reaches a probability of certainty in 450 to 500 years. In many stands the fire cycle is much shorter than this--as short as 8 to 15 years in ponderosa pine stands.

Certain tree species in the northern Rocky Mountains owe their present widespread occurrence, if not their very existence, to fire. These include western larch, lodgepole pine, and western white pine. Fire is responsible for the occurrence of ponderosa pine over the greater part of its range in the northern Rocky Mountains; without fire, Douglas fir and grand fir would occupy areas where ponderosa pine now occurs but is not climax. Fire is also responsible for larger acreages of Douglas fir stands and to a lesser extent grand fir stands where these species are not climax. It has also favored the distribution of Engelmann spruce at the expense of subalpine fir.

In the Pacific Northwest, Douglas fir is mainly a pioneer or seral species that reproduces after fire or other disturbances. Much forest land in western Washington and Oregon is occupied today by relatively young seral stands that have followed clearing, logging, and wildfire (Franklin and Drness, 1973). Carelessness, often associated with clearing and logging, has resulted in extensive fires during the dry, warm summers and falls. Single burns usually reforest well from individual trees or groups of trees left by the fast-moving fires; areas burned repeatedly often remain treeless for many years. (It is such multiple burns in the Rocky Mountains that contribute to excellent browse conditions and elk habitat.)

Fire also has been important in shaping the vegetation in the ponderosa pine zone in Washington and Oregon. Competing tree species, such as grand fir and Douglas fir, are considerably less fire tolerant, especially in the sapling and pole size classes (Franklin and Dyrness, 1973). As a result, periodic fires in the past served to maintain ponderosa pine in ecotonal areas where, without fire disturbance, the climax tree species would have attained dominance (Weaver, 1955, 1959, 1961).

The usual forest vegetation on dry sites in Alaska is white spruce, paper birch, and balsam poplar. Following a fire, fireweed and willow reinvade the site, and an almost immediate replacement by aspen and birch occurs. Eventually white spruce stands are established, but the process is often slow. On wet sites, and because of the semiserotinous cones on black spruce, the pattern is generally one of rapid replacement by black spruce after fire. The present-day mosaic of vegetation in interior Alaska is closely related to past fire history. Nearly all stands are less than 150 years old, and most represent earlier stages of fire succession.

In addition to effects on plant succession, fires in the taiga significantly affect permafrost and soil nutrients. Burning the insulating organic layer of permafrost soils increases the depth of the annual thaw, or active layer. There also seems to be a release of nutrients and a fertilizing effect of fire on the organic soils in Alaska.

Thus, a high percentage of the vegetation, within all forest zones of the coniferous biome, is at one stage or another of succession following past fires.

Human Interest Values

Land Uses

Mining of gold and silver, and later timber harvesting, were the principal attractions of the western mountains. Although many of the early mining settlements have either disappeared or are ghost towns today, others, more favorably situated, survived. In certain locations, mining still provides significant income and employment. Many rural communities in Alaska, Colorado, Idaho, Montana, Wyoming, Washington, and Oregon which had their greatest population prior to 1920 have since decreased. Large national forests and parks in the area have virtually no permanent year-round habitation. Forest products, mining, agriculture, and tourism are the mainstays of the economy.

Communities tend to be small, and are oriented to logging, ranching, or mining that may occur in the area. A phenomenon that began after World War II and has increased alarmingly in some parts of the region having nonexistent or weak local land-use controls has been the development of "speculative" home sites. Frequently located in remote rural areas, these recreation subdivisions more often than not have failed to develop as portrayed in the sales brochures.

Recreation-tourism is growing rapidly in importance throughout the biome. In areas with outstanding resources, such as the Yellowstone Park area, or Aspen, Colorado, tourism is the mainstay for local communities. The Pacific Crest Trail, routed along the crest of the Cascade Mountains, stretching from Canada to Mexico, leads to points of scenic beauty accessible only by pack horse or foot and annually receives increased use. Throughout the montane region Federal, State, county, and municipal organizations as well as private enterprises have been active in the development of scenic and recreation resources. Hunting, fishing, sightseeing, picnicking, and camping, and winter sports are the predominant types of recreation activities.

The Pacific coast forms the western boundary of the coastal sub-biome. The proximity to the ocean adds to the recreational diversity of the area. Outdoor activites such as swimming, fishing, and camping are some of the more common forms of recreation activity. In Alaska's vast Interior, recreational use can be expected to increase rapidly. Current estimates show 9.8 million acres of natural lakes and reservoirs, 50,000 miles of fishing streams, 255 million acres of big- and small-game habitat (containing 760,000 big-game animals) and 67 million acres of waterfowl habitat located on the public lands, most of which are within the taiga region. Estimated recreation visits to the public lands within the region during 1971 exceeded 5.8 million. In addition, the streams and lakes yielded an estimated 69.5 million pounds of commercial fish harvested in 1971 (U.S. Department of the Interior, 1971).

Aesthetics

The montane coniferous forest and, to a lesser degree, the northwest coastal coniferous forest, provide some of the most spectacular scenery in the Western United States. Such natural attractions as Yellowstone Park, the Grand Canyon, and numerous other lesser known sights located throughout the montane region annually attract hundreds of thousands of sightseers. Further west the coastal redwood forests of northern California and the rainforests of the Douglas fir region of western Oregon and Washington offer a more or less continuous panorama of towering forest broken by occasional streams tumbling from the Coast Range Mountains to the Pacific Ocean. Less apparent from the ground except in localized areas, man's intrusion into the coastal forest with roads, power transmission corridors, and timber harvest activities create harsh contrasts when viewed from the air.

Landforms vary from the rounded foothills of the Cascades and Coastal Range to the angular peaks of the Rockies, from relatively flat mesas and basins to nearly vertical canyons. Natural lines occur more often in the environment of the montane than in either the coastal or taiga sub-biomes. These may occur as abrupt changes in vegetation types caused by soil changes, avalanche paths, or rock intrusions. They may occur as horizontal deposition lines on the face of an exposed cliff or cut bank.

Scale is frequently so vast as to be overpowering to those more accustomed to urban surroundings. The extreme vertical relief common to the mountains is frightening to some. To others the solitude of the mountains and the remoteness of the taiga coniferous forest offer a welcome contrast. The wide variety of forms, textures, colors, and natural lines are what make the scenic values interesting, while vastness of scale and distance bring feelings of isolation and solitude to those who live within or visit this region (U.S. Department of the Interior, 1972b).

Geological

The montane contains geologically interesting features left by glaciation. Included are morains, lakes, U-shaped valleys; erosion features like canyons, pinnacle peaks, and mudlows; volcanic features such as lava flows, eroded ash beds, dikes, exposed plugs, calderas, hot springs, and geysers.

The taiga also shows evidence of glacial action. Such structures as moraines, drumlins, glacial lakes, and other features occur, along with features associated with permafrost and its actions such as pingos, thaw lakes, beaded drainages, etc.

The northwest coastal is edged with an interesting eroded coastline of natural arches, isolated rock islands, sand dunes, and steep cliffs. The higher elevations contain canyons, volcanic features, caves, and faulting evidence (U.S. Department of the Interior, 1972b).

Archeological

Early man's entry into the New World from Asia via a Bering Strait land bridge, estimated to be 1,000 miles wide when the seas were at their lowest, is believed to have occurred between 20 and 40 thousand years ago. Radiocarbon-dated remains going back to about 10,000 B.C., show well-developed stone-chipping techniques and hunting skills adapted to the taking of large animals. Most evidence comes from game kill sites and stratified cave deposits (U.S. Department of the Interior, 1970).

The montane forest was utilized for food gathering and hunting by the desert culture that developed in the trans-Rocky Mountain west.

In the taiga, the Old Bering Sea culture developed into the early stages of Eskimo culture based on the hunting of sea animals. Further inland in the Alaskan Interior the subartic culture, based on the Old Cordilleran and Big Game hunting Traditions, developed into the Northwest Microblade tradition of people who lived by hunting caribou, elk, buffalo, and fishing. The Microblade Tradition is felt to have provided the core for the Denetasino Tradition which became the Athabascan-speaking Indians. Archeological sites are mostly campsites along streams and lakes and on ridgetops with occasional rock shelters.

The northwest coastal coniferous forest was the home of the Northwest Coast culture. Essentially a river or river-mouth culture, oriented around salmon fishing. The Northwest Coast culture is noteworthy for its vigorous and distinctive art and great use of wood. Village sites were located along streams and near sheltered inlets along the coast and consisted of both pit and surface houses. Occasional rock shelters and some campsites away from the streams are found.

Historical

The montane shares its history with that of the nearby grasslands and desert. Many of the early settlements started as mushrooming camps that later blossomed into the present-day cities of Baker, Lewiston, Boise, and Helena. Most of the early mining camps became empty shells as the ore petered out and their inhabitants moved on to greener pastures. Some of these "ghost towns" such as Montana's Virginia City have survived the ravages of time and today are popular tourist attractions. Other early settlements grew up around military forts and trading posts located along exploration and immigration routes to the West. Today many of these early sites have been given national designation as historical sites and monuments.

The early history of the northwest coastal area developed around fur trading, lumbering, and to a lesser degree, mining. Spain, England, Russia, and the United States all laid claim to this region through discovery, exploration, and occupation. One of the earliest white settlements was Astoria, established as a fur-trading post by John Jacob Astor's Pacific Fur Company. This company was later sold to the Hudson's Bay Company which relocated the headquarters a hundred miles up the Columbia from Astoria and established Fort Vancouver, that exists today as a national historic site (Oregon State University, 1968).

Approximately 20 years after the establishment of Fort Vancouver the few American settlers in the Oregon country, tired of living under Bri tish laws and the authority of the Hudson's Bay Company, met at Champoeg, near Newberg, and voted to establish a provisional government until Congress would extend jurisdiction over them. This was the first American government to be established west of Iowa. Today Champoeg is a State park (Oregon State University, 1968).

Scattered throughout the coastal forest are remainders of the region's early history. Old mining and logging camps, remnants of military posts, and preserved homes of early pioneers are some examples.

The taiga of Alaska was initially claimed and explored by Russia. Early trading posts and missions (some still in use) were established during the period of exploration. After purchase by the United States the area experienced a gold rush which created numerous "boom and bust" settlements; the relics of many still exist. Many of the present native settlements occupy sites that were established hundreds of years ago. Some remain little changed from primitive times.

Cultural

Numerous Indian groups currently make their homes in various locations scattered throughout or nearby the montane forest. Most of these reside on the following reservations which extend into the montane forest: Coleville, Yakima, Coeur d'Alene, Nez Perce, Flathead, Warm Springs, Crow and portions of the Navajo, Uintah and Ouray, Pueblo, Fort Apache, and Tule River Indian Reservations. Many of these groups derive part of their economic and spiritual sustenance from the coniferous forest.

The taiga forest of Alaska contains one of the largest remaining native American groups still living in much the same way as they have since contact times. They depend to a large extent upon the taiga for their livelihood.

The northwest coastal forest contains two small Indian reservations, the Quinalt and Hoopa Valley Resrvations. Both rely to some degree on the coastal forest for their livelihood.

TUNDRA BIOME

The tundra biome encompasses all of the area north and west of the taiga forests in Alaska. This treeless zone extends poleward from the Brooks Range to the Arctic Ocean, and includes the Seward Peninsula, the Bering Sea coast, the Alaska Peninsula, the Aleutian Islands chain, and the lower portion of Kodiak Island. The extent of this biome is shown in figure II-32. Figures II-33 and II-34 are photographs of arctic Alaska and western Alaska tundra landscapes, respectively.

Virtually all of the tundra region of northern Alaska has been in Federal ownership until recently. However, State land selections and native claim selections surrounding coastal settlements will reduce the acreage of Federal lands over the next several years, under the Alaska Native Claims Settlement Act.

Topography

In northern Alaska, the tundra extends from flat coastal areas along the Arctic Ocean to moderately and steeply sloping mountains with 1,000 to 3,000 feet of relief at the west end of the Brooks Range. Flat, open plains extend southward along the west coast and along the northwest coast of the Seward Peninsula. Low to high, gently sloping hills with 500 to 1,000 feet of relief are the predominant topographic features of the north and central parts of the Seward Peninsula. The peninsula's southern coast is predominantly low, gently sloping mountains with 1,000 to 3,000 feet of relief. The steeply sloping mountains along the west end of the peninsula lack vegetative cover; the tundra vegetation in this area is restricted to a few valleys and the gently sloping hills, and flat areas near the coast. South of the Seward Peninsula, the topography varies from flat plains along the Yukon and Kuskokwim Rivers to high, moderately sloping mountains with over 3,000 feet of relief along the southwestern coast. In the Aleutian Islands, topography varies from smooth, gently sloping plains along the northern coastal areas to high rugged mountainous areas; relief varies from island to island.

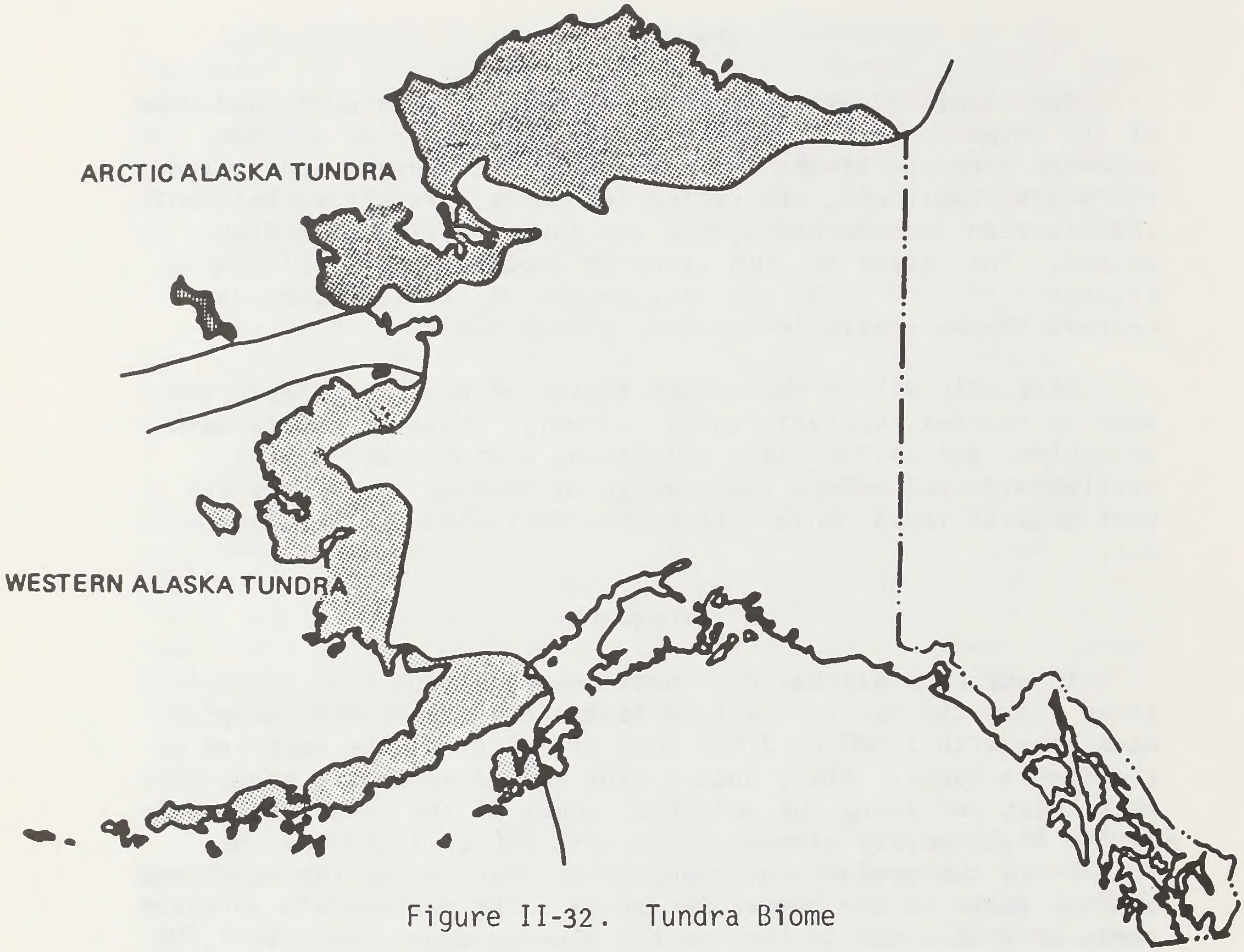
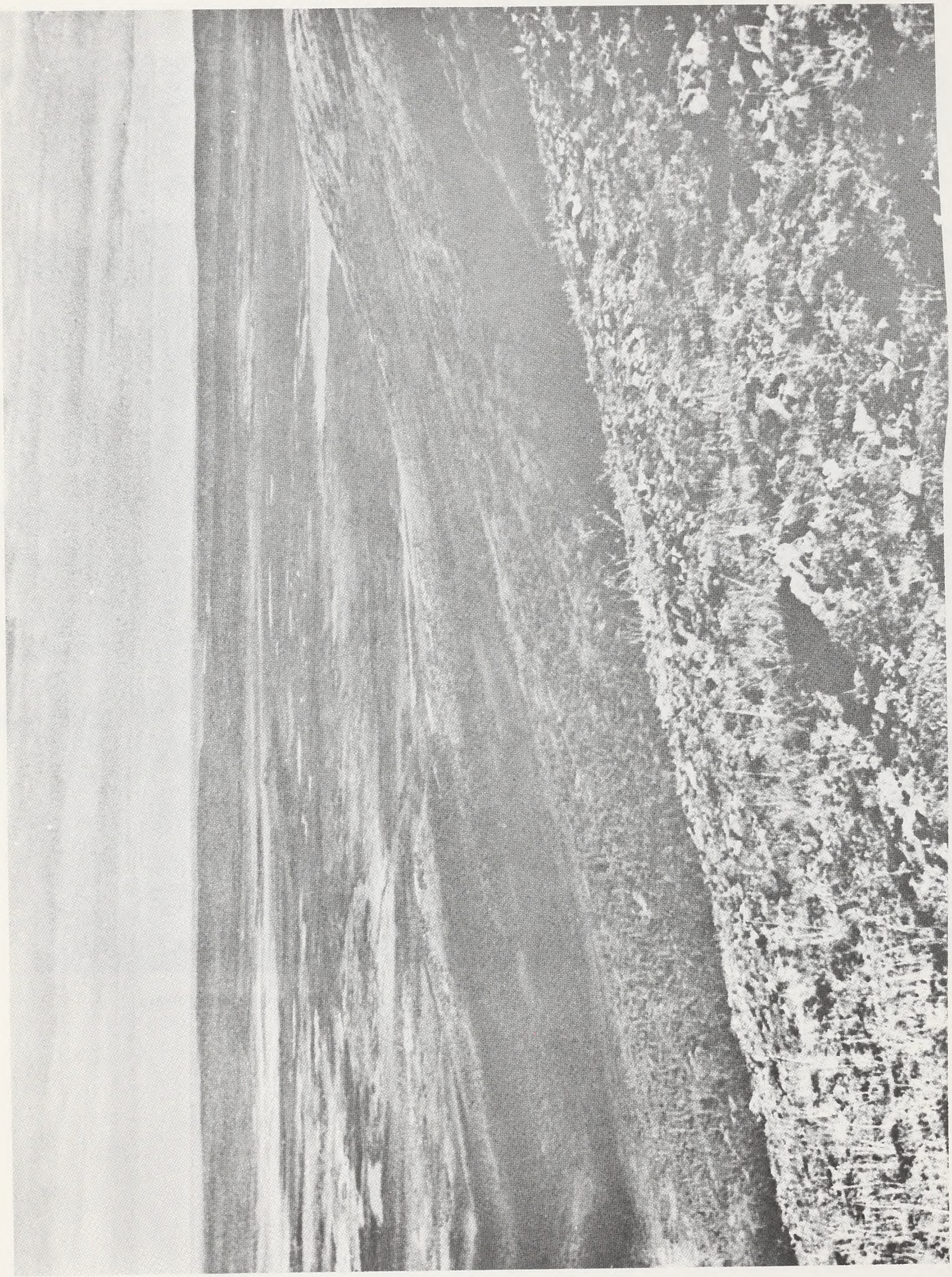


Figure II-32. Tundra Biome

Bureau of Land Managemement Photo

Figure II-33. The Arctic Alaska Tundra



Bureau of Land Management Photo

Figure II-34. The Western Alaska Tundra

Soils

The soils of the north slope coastal areas; the areas around the mouth of the Kobuk, Noatuk, Yukon, and Kuskowim Rivers; the north coast of the Seward Peninsula; and the north coast of the Aleutians, are formed on Quaternary sediments. Soils in the Brooks Range and on the Seward Peninsula are formed mainly on sediments of Upper Paleozoic Age. The mountains which reach the ocean along the southwest coast of Alaska are composed of Cretaceous Age sediments while the islands of the Aleutian chain are predominantly Quaternary and Tertiary Age volcanic rocks.

Permafrost, an important characteristic of the tundra is found throughout the biome. There are some areas where it is not continuous due to climatic and terrain factors. The permafrost zone along the northern coastal area is as much as 2,000 feet thick. Though it is generally a continuous layer to the far south of the Brooks Range, it thins southward as the ice-soil ratio decreases.

Disturbance or removal of the mat of vegetative material which insulates the permafrost can cause rapid soil erosion and massive slumping. The soil's susceptibility to such damage is directly proportional to its water content. Dry, gravelly permafrost soils are affected little by disturbance-induced thawing. Wet, silty (or ice-rich) permafrost solis are highly susceptible to oozing slumage when thawed (Hubbert, 1967).

Minerals

The leasable minerals, coal and phosphate, are found primarily in the Cretaceous and Tertiary sediments on the north and south slopes, respectively, of the Brooks Range in arctic Alaska. North slope coal lies in the same general area found to contain large oil and gas reserves. The arctic coal ranges from anthracites through subbituminous to medium and high volatile bituminous. Sulfur is found near the western end of the Alaskan Peninsula and is the result of volcanic activity.

The locatable minerals, gold, copper, platinum, silver, lead, zinc, tin, fluorspar, barite, antimony, and iron are to be found in western Alaska on the Seward Peninsula. These are related to the Paleozoic sediments.

The famed Alaska North Slope oil and gas field underlies the arctic Alaska tundra. A relatively small segment of the Alaskan pipeline will pass through this area.

Areas having oil and gas potential located within this subbiome are in large part included within the following categories: (1) Naval Petroleum Reserve No. 4; (2) Arctic National Wildfire Range; (3) State land selections under ANCSA (Alaska Native Claims Settlement Act); (4) regional land deficiency withdrawals under ANCSA; (5) native claims under ANCSA; (6) withdrawals for possible inclusions in the Four National Systems (D-2 lands) under ANCSA and (7) village land deficiency withdrawals under ANCSA. Currently, however, no Federal lands are available for leasing.

No significant oil and gas areas have been identified on the Seward Peninsula. Some small oil and gas deposits have been identified, however, exploration activities in this area undoubtedly will await exploration of the better areas in Alaska, as well as development of oil and gas transportation and production facilities that would bring costs down, making the smaller oil fields economically competitive.

Water

Surface waters of the tundra biome empty into the Bering, Chukchi, and Beaufort Seas. Lakes, ponds, and marshes are very important to wildlife. Average annual runoff varies with annual precipitation. However, little is known about actual water evapotranspiration, the tundra is considered a water surplus area.

The quality of most surface waters is good. The suspended-sediment content of glacier-fed streams and rivers is high. Streams that flow from extensive swampy areas are usually high in organic and iron content because the drainage of such areas often is restricted by impermeable subsurface materials, including permafrost.

Climate

The tundra biome has a relatively dry polar climate in the north and a rainy climate with severe winters in the south. The average annual precipitation ranges from 8 inches along the Arctic coast to 16 inches at Nome, 20 inches at Bethel, and 60 inches at Kodiak.

During winter, the Arctic high pressure system brings a dry, cold flow of air to the northern part of the biome. At the same time, the high pressure system picks up moist air from the Gulf

of Alaska and deposits it along the western coast. In the summer, a low pressure system develops in the Bering Sea and produces a flow of moist air over the west and south coasts and the interior of Alaska. As a result, considerable precipitation falls in July, August, and September (figure II-35).

While summer temperatures are not greatly different from one tundra region to another, there are greater variations in the winter. In the north during January, air flow from a cold continental air mass causes temperatures to average -10°F. Mean monthly temperatures during the winter are warmer in the south; at Nome, the January temperature averages -5°F and at Kodiak, the temperature in January averages 30°F. Average July temperatures range from 40°F in the north to 50°F in the south (figure II-36).

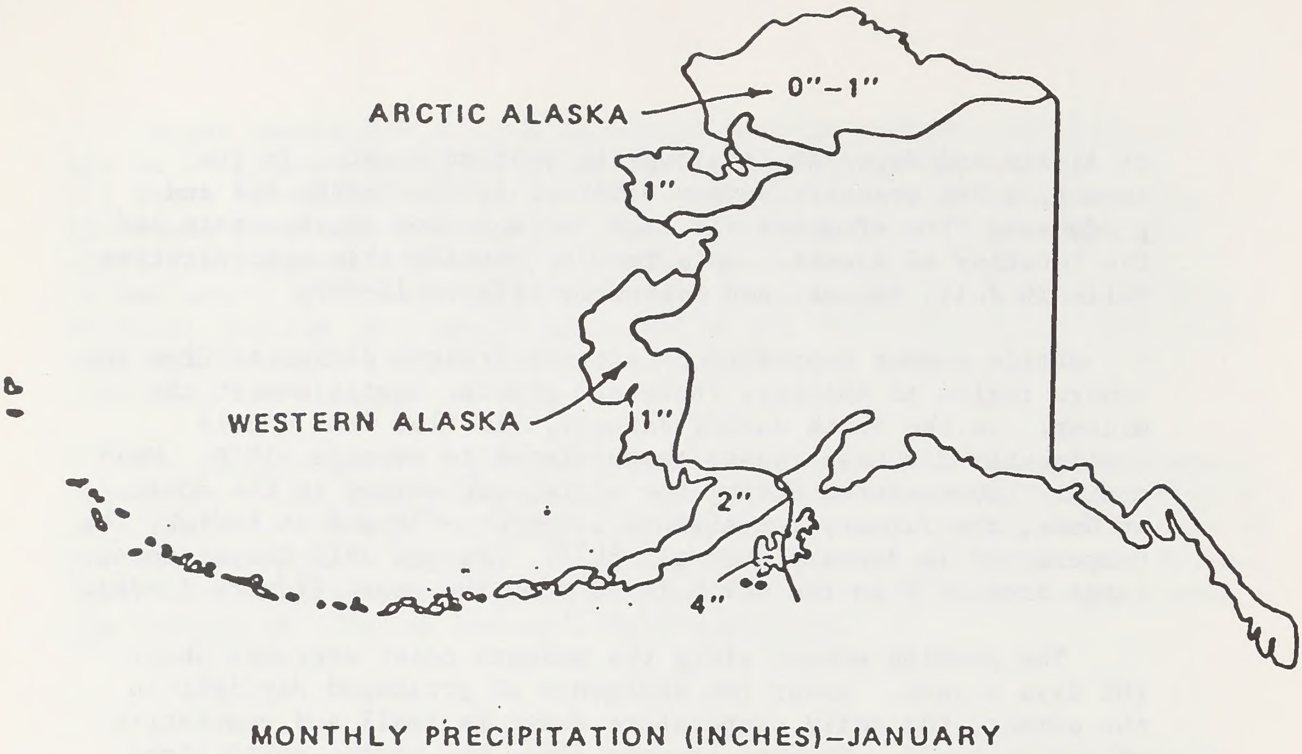
The growing season along the western coast averages about 100 days a year. Under the influence of prolonged daylight in the summer, the daily temperature range is small and vegetative growth is rapid. Growing seasons along the Arctic north slope are shorter than on the west coast, ranging from less than 30 days on the north slope to over 150 days on Kodiak Island.

Vegetation

The tundra biome comprises three plant associations: the moist tundra (*Euphorium*-*Carex*-*Cladonia*-*Cetnaria*); the wet tundra (*Cladonia*-*Cetnaria*-*Salix*-*Sparganium*-*Potamogeton*); and the alpine tundra (*Erieaceae*-*Avena*-*Empetnum*) (U.S. Department of the Interior, 1976).

Vegetation in the tundra biome is structurally simple and is dominated by grasses, mosses, and sedges of low stature (U.S. Tundra Biome Program, 1971). Herbaceous and woody vegetation such as willows and birch is also present but is generally low or prostrate. However, 10-to-12-foot-tall willows may form impenetrable thickets in gullies and other sheltered areas. In other places there may be much bare, stony soil with only meager amounts of plant life.

Essentially an Arctic grassland, the treeless tundra supports many lichens and mosses. During the short growing season, temperatures often are near the lower limit of biological activity (32°F average in the warmest month). Nearly all plants are perennial, and annual production is low. Most plants appear xerophytic, having stiff, hard, leathery leaves with thick cuticle. The short growing season forces the plants to rush through their life cycles; in many cases they are often frozen again while still in their flower or fruit stage. The total



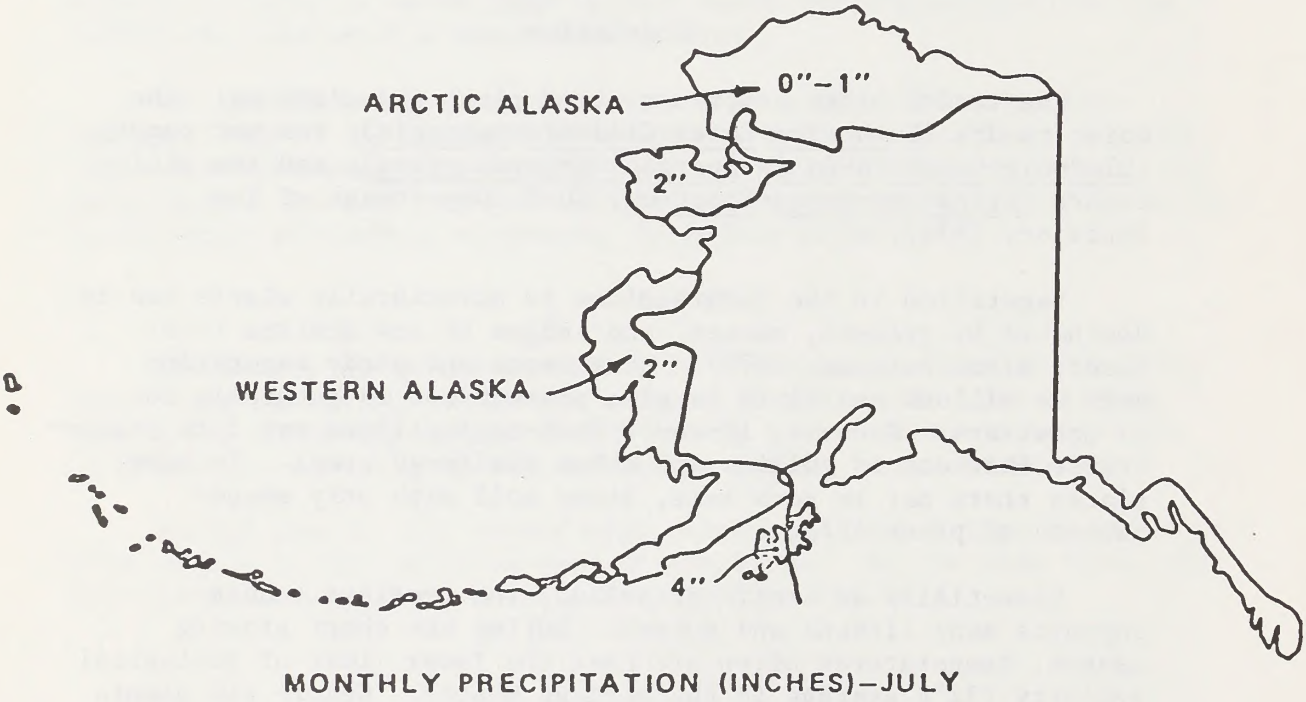
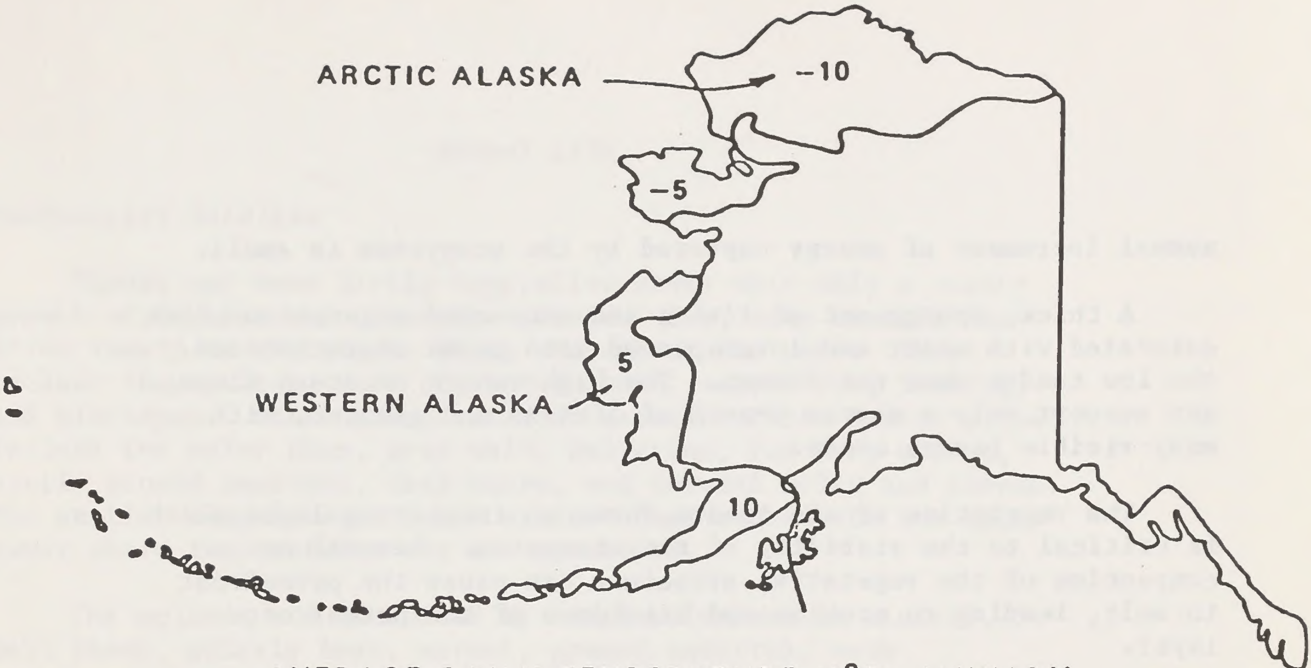
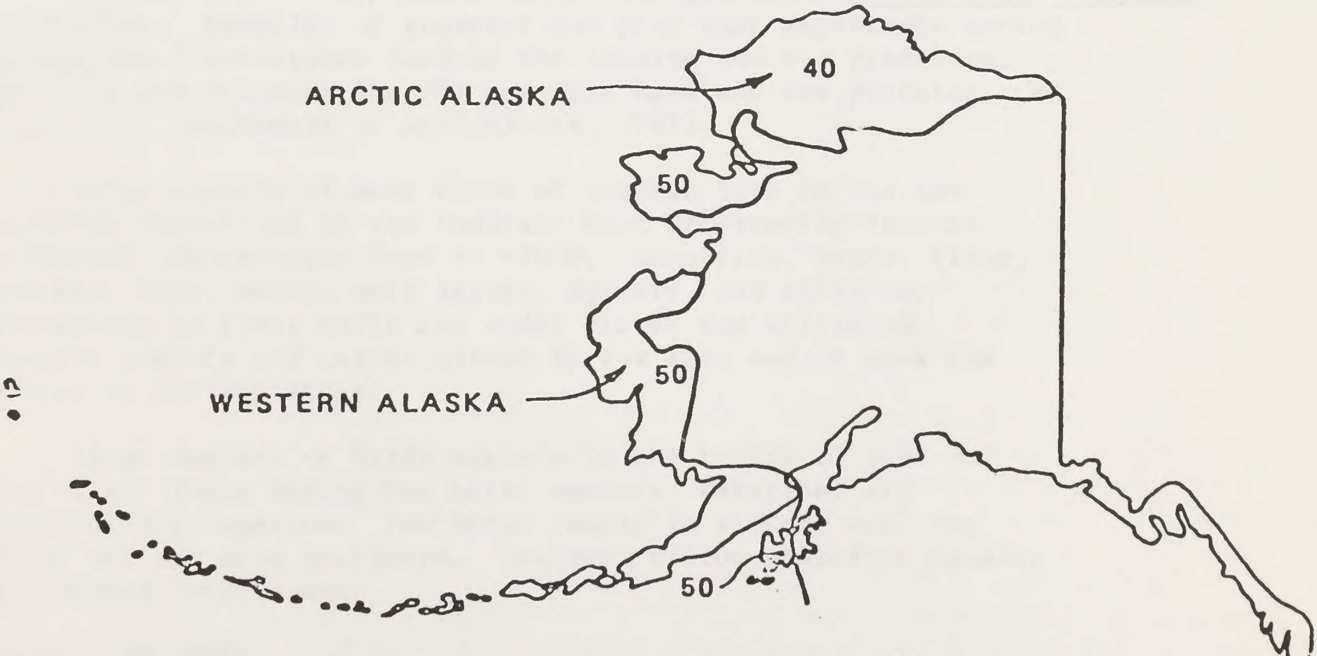


Figure II-35. Average January and July precipitation in the tundra biome



AVERAGE DAILY TEMPERATURE (0°F)–JANUARY



AVERAGE DAILY TEMPERATURE (0°F)–JULY

Figure II-36. **Average daily temperatures in the tundra biome in January and July**

annual increment of energy captured by the ecosystem is small.

A thick, spongy mat of living and undecayed vegetation often saturated with water and interspersed with ponds characterizes the low tundra when not frozen. The high tundra on steep slopes may support only a sparse growth of lichens and grasses, with many visible barren areas.

The vegetation of the tundra forms an insulating layer which is critical to the stability of the ecosystem. Removal or compaction of the vegetative structure can cause the permafrost to melt, leading to erosion and breakdown of the permafrost layer.

In comparison to other areas, there are only a few endangered plants in Alaska. Examples in the tundra biome are: sedge (Carex jacobi-peteri); bladderpod (Lesquerella arctica var. scammanae); pennycress (Thlaspi arcticum); and locoweed (Oxytropis kokrinensis) (Federa Register, July 1975).

Animal Life

Terrestrial Wildlife

Tundra may have little vegetative cover with only a scanty growth of lichens and other low plants. Yet, many mammals and birds remain in the tundra biome throughout the year. These include the caribou, musk ox, arctic hare, arctic fox, lemming, and ptarmigan. Other characteristic mammals of the Arctic slope include the polar bear, gray wolf, wolverine, red fox, marmot, arctic ground squirrel, deer mouse, and several moles and shrews. The smaller mammals make their winter homes underneath the snow cover where temperatures are not so severe.

The uplands are inhabited by caribou (except in winter), Dall Sheep, grizzly bear, marmot, ground squirrel, rock ptarmigan, horned lark, and Lapland longspur.

Seal, walrus, and polar bears inhabit the coastal margins or the drift ice, where they feed mainly on marine life.

The populations of some animals vary greatly from one year to another. Examples of predator and prey that experience marked population fluctuations include the lemming and its predators, the owls and jaegers; and the snowshoe hare and its predator, the lynx (U.S. Department of Agriculture, 1965).

Large numbers of many kinds of insects live in the low marshier elevations of the tundra. Most hibernating insects withstand temperatures down to -50°F. Mosquitos, gnats, flies, beetles, bees, wasps, moth larvae, spiders, and mites may overwinter in plant tufts and under stones and driftwood. Aquatic insects and larvae either burrow into mud or pass the winter in the egg stage.

Large numbers of birds migrate to the tundra to nest and rear their young during the brief summer. Waterfowl are particularly numerous. Few birds remain in winter; even the snowy owl may move southward. However, willow ptarmigan usually are present year-round.

Aquatic Wildlife

The tundra lakes, ponds, and bogs do not support large populations of aquatic life due to a lack of minerals and nutrients. Resident fish grow slowly but may grow to a large size when left undisturbed. Characteristic fish are chars, grayling, and whitefish. The chars are lake trout (mackinaw) and

arctic char. The arctic grayling is abundant and well distributed in tundra waters. Shellfish inhabit the major rivers. The chum and pink salmon fry migrate to sea upon hatching.

Endangered Wildlife

Endangered species include the arctic peregrine falcon (Falco peregrinus tundrius) which breeds above the Arctic Circle, the American peregrine falcon (Falco peregrinus anatum) and the Aleutian Canada goose (Branta canadensis leucopareia), which nests on some of the islands in the Aleutian Islands chain. The status of the polar bear (Thalarctos maritimus); pine marten (Martes americana); wolverine (Gulo luscus); and Canada lynx (Lynx canadensis) are undetermined. The musk ox (Ovibos moschatus), once extinct in Alaska, has been reintroduced. It is uncertain whether the species will be reestablished (Federal Register, Sept. 1975).

Domestic Livestock

Approximately 21,000 square miles of the tundra biome are grazed by about 36,000 native-owned, domestic reindeer (Rangifer tarandus). These comprise approximately 18 herds located on the Seward Peninsula; Nunivak, St. Lawrence and Hagemeister islands; and near the coastal villages of Unalakleet and Stebbins (Pegau, 1968).

Reindeer were introduced to Alaska from Lapland, near the turn of the century, to provide a reliable source of meat for the Eskimos. Since introduction, reindeer numbers have fluctuated from a high of about 640,000 in 1932 to a low of 25,000 in 1950 (Pegau, 1968).

The reindeer industry is important to specific village economics. Income is derived from selling meat, primarily to local markets and from selling antlers to oriental markets for medicinal puposes.

On the Seward Peninsula, fires periodically burn on reindeer ranges but, due to the vast areas and lack of manmade improvements, the fires have not materially affected the reindeer industry.

Wild Horses and Burros

There are neither wild horses nor wild burros in the tundra

biome.

Human Life

Conditions of the tundra biome have limited settlement to small villages along the coastline and major rivers. Most inhabitants, aboriginal and non-native alike, depend on the surrounding natural resources for subsistence or livelihood.

Eskimos, who make up about one-half of the State's native population, live near the Bering and Arctic seacoasts and coastal rivers. Indians generally live along the Yukon, Kuskokwim, Tanana, Copper, and other interior rivers. The Aleutian people are the smallest native group and have traditionally lived along the Alaskan Peninsula and Aleutian chain of islands.

The native Alaskan population increased 27 percent from 1950 to 1960 and 19.5 percent from 1960 to 1970. Improved health care has partially arrested high infant death rates, but the native population continues to have more health problems than the national norms.

Role of Fire

Few cases have been documented regarding fire's role in the tundra. Scotter (1971) reported that fires are rare and usually limited because of the mixture of wet and dry tundra and barren areas of rock or sand. However, BLM records show that many fires, some in excess of 100,000 acreas, occur periodically on the Seward Peninsula. Barney and Comiskey (1973) documented the occurrence of lightning fires in the tundra, but the extent of such fires is unknown. Wein's research (1971) in cottongrass tussock tundra established that burns tended to be light because of the wet soil profile, and that no vascular species were completely eliminated by fire. Major vascular species and some mosses showed rapid postfire recovery, although reestablishment of lichens may take a long time. Wein concluded that if other tundra communities regrow in similar fashion, a burn may be difficult to detect in a very few years after a fire.

Cochrane and Rowe (1969) reported that although conditions are not conducive to burning, fire can and does occur along the northwest shore of Hudson Bay and probably throughout the tundra:

> "While fire can occur on a variety of topographic sites, its patterning over the landscape appears to be controlled by the vegetation itself. The combustibility and quantity of tundra vegetation fuel is variable, and only lichen mats, low heath and mixed lichen-heath communities appear capable of propagating continuous fire. These communities are normally

present on relatively exposed sites where: (a) winds are strong, (b) the soils are well drained, (c) the greatest depth of thaw above the permafrost level occurs. The most likely fire weather is in the long days of summer when evaporation has depleted moisture from the top few inches of soil on ridge crest and slopes."

Their field observations suggested that tundra fires moved downwind easily but backing fires were stopped by minor obstacles. Low embankments, frost fissures, rock outcrops, and gaps in the vegetation cover provided effective barriers to the advance of fires in an upwind direction.

Human Interest Values

Land Use

Fishing and hunting historically have been the sole means of survival for natives on the tundra. Income and cost of living for Alaskans of European descent is much higher than in the lower 48 States. The Eskimo trying to live according to non-native economic standards, on an Eskimo income, is in a serious predicament. Public assistance represents a significant portion of the natives' cash income, and employment opportunities are poor (U.S. Department of the Interior, 1972a). Conflicts between native culture and modern society present a difficult problem. Many native peoples wish to adopt certain aspects of modern society, but differences between cultures make the transition difficult. Native cultures and values are understood by few non-natives.

Minerals and mining have been responsible for much of the exploration and development of the tundra. Gold discoveries on the Seaward Peninsula resulted in a flurry of development. This was followed by intensive prospecting throughout the region. Several minerals in additions to gold were discovered and mined. More recently, sizable oil and gas reserves were discovered at Prudhoe Bay, on the north slope, as discussed earlier. Considerable development is expected as these reserves are tapped.

Tourism is expected to be an important source of income in the future. Hunting and fishing are steadily increasing, aided by the use of small aircraft and all-terrain vehicles, such as the snowmobile.

Aesthetic Values

The landform in the tundra is low, rolling, or nearly flat topography similar to that of the grasslands. The texture is the extremely fine, soft texture of the tundra vegetation. Color is the soft, gray-green monotone of vegetation interrupted only by an occasional stream. Lines are almost non-existent. Scale, as in the grasslands, is difficult to define. Because the tundra is so plain and so uniform, almost any disruption or intrusion immediately becomes the focal point for the observer. Except for landforms such as the Brooks Range and other more gentle mountains and hills, the tundra does not hold a great deal of interest for most viewers (Arps, et al., 1970).

Geological

Features of geological interest are limited. There are the normal effects of glaciation, coastal erosional features, and such results of extreme freezing action on the land surface as pingoes, which are small raised islands of ice. The Aleutian Islands chain contains evidences of volcanic formations. At the base of the Alaska Peninsula is Katmai National Monument containing the valley of 10,000 Smokes, which has active volcanic features. Two small areas of sand dunes are located along the tundra-taiga transition zone.

Archeological

The tundra biome is basically synonymous with the Eskimo and Aleut culture areas, or the Arctic Tradition. The Aleuts, linguistically related to the Eskimos, live on the Aleutian Islands chain. Because of its proximity to Siberia, western Alaska continually received stimuli from the Old World (Willey, 1966).

There are evidences of both the Old Cordilleran Tradition and the Big Game Hunting Tradition in earliest Alaska. This was followed by the Northwest Microblade Tradition, characterized by numerous microblades struck from conical cores. The next tradition, known as the Arctic Small Tool Tradition, is characterized by a unique style in fine pressure-flaked flint and small tools. Last to be found is the Eskimo Tradition, which probably began some 4,000 years ago. All of the traditions occurred along the seacoast for the most part. All cultures lived by hunting large sea animals, catching fish, and hunting caribou and other animals inland. Many of the better gravel bars and sand pits were occupied by pit and surface houses for thousands of years, each beach strand frequently representing a

different time period or culture.

Historical

The history of the tundra includes early periods of exploration by the English, and Americans. A trading period involved mostly the Russians and later some Russian settlements. Purchase of the Alaskan Territory by the United States in 1867 brought increased exploration by the Americans. Gold rushes in the late 19th century and early 20th century stimulated some settlement. World War II and the ensuing "cold war" brought the military to remote locations. Japanese military forces occupied parts of the Aleutians during World War II. Designated historic landmarks found within this biome are listed in the National Register of Historic Places.

Cultural

The Eskimos and Aleuts are among the largest groups of native people living a lifestyle resembling that a contact times. However, changes have occurred more rapidly in recent years. Old subsistence patterns have begun to break down. More dependence is put on white man's foods, equipment, and clothing. The sled dog is disappearing as the snowmobile takes its place. The kayak and umiak are giving way to the outboard motorboat.

The culture and traditions are disappearing, perhaps to be lost forever.

A cultural reinforcement effort has been launched, however, to teach forgotten native crafts, and to maintain and document the native languages and folklore.

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PART III

ENVIRONMENTAL IMPACTS OF THE FIRE MANAGEMENT PROGRAM

This section assesses the impacts of the proposed fire management activities (presuppression, suppression, post-suppression, and prescribed fire) on the nonliving and living components of the five biomes.

IMPACTS FROM PRESUPPRESSION PRACTICES

Soil

Prevention and presuppression actions having a direct bearing on soil condition include hazard reduction and facility construction.

Hazard reduction involves either slash disposal or reduction of natural fuels. Perhaps the most critical practice relating to soil impacts is the piling and burning of slash. Since heat intensity and duration determine depth of lethal heating for organisms and extent of removal of any organic layers, such concentration of fuel increases these impacts. The soil under such burned piles is often rendered incapable of supporting vegetation for several years.

All burning to reduce vegetative residues leads to some loss of nutrients such as nitrogen, boron, sulfur, and phosphorus (Moore and Norris, 1974). However, certain important nutrients are usually made more available to plants and stimulate establishment and growth unless too soon lost through leaching from the soil. These nutrients include calcium, potash, phosphorus, and nitrogen.

Wettability of soils tends to decrease with fire intensity, as does infiltration capacity.

The construction of roads, trails, firebreaks, and other facilities accelerates soil erosion from cleared areas. Such operations are also conducive to increased soil compaction from heavy equipment operation and rainfall action on bare soil.

Water

Hazard reduction by the use of fire should be conducted to minimize adverse effects. Burning of slash or natural undergrowth is done when the soil mantle is moist and the fire intensity may be kept relatively low. Under such control, conditions are not likely to develop where massive runoff and erosion will occur, nor where the soil will be damaged by heat to the extent of significantly increasing water repellancy.

Ash residues release nutrients benefiting vegetation. Ash and soil particles entering streams and lakes may produce undesired sediment loads and salinity charges.

Mechanical construction of fire control facilities will have some impact on water. Roads and firebreaks are the facilities usually involved.

Air

An obvious technique for reducing size and number of wildfires is to remove or reduce the hazard--the material that would burn--or break it up into smaller compartments by removing strips of it. Similar operations are involved in removing the hazard from areas where the risk also is very high, e.g., cleanup of roadsides and around heavy use areas. Removal or reduction of the fire hazard in forest and range areas is often done by the skillful use of fire.

Where fire is used, smoke is emitted, but the amount and behavior of the smoke varies greatly--with fuel type, its moisture content, fuel size, arrangement, and loading, ventilation, the manner of burning, and the size of the area to be burned. Impact of the smoke on the environment also varies with weather factors affecting dispersion, with amount and kind of pollutants already in the air, and with location of emitted smoke in relation to places where additional smoke is definitely not wanted. Impacts of smoke have been considered sufficiently important in metropolitan situations to require severe regulation or even prohibition of open burning. It is therefore imperative that the impacts of the fire management program on air quality are closely examined.

Where prescribed fires 1/ are used as a presuppression-preventive activity to reduce fuel hazards, particulate production from the fires can cause adverse impacts on air quality. The major impact of particulates is in the reduction of visibility, affecting recreationists, airports, highways,

forest dwellers, and communities downwind from burn area. Smoke from prescribed fires can also adversely affect people with respiratory problems.

However, prescribed burning for hazard reduction reduces detrimental effects of smoke emissions from subsequent uncontrolled wildfires. Wildfires produce three times as much pollutant material as prescribed fires per unit weight of fuel, and usually consume about three times as much fuel (Cooper, 1972). Thus, one of the beneficial impacts of prescribed burning lies in the scheduling of fires to minimize adverse effects on air quality, and limit the unscheduled emissions of particulates from wildfires. Selecting time of ignition, fuel moisture conditions, season of year, location and duration of fire, and meteorological conditions can control particulate production and smoke dispersion.

A deep mixing layer with adequate wind is a combination favoring good dispersion of smoke. The most favorable afternoon dispersion conditions are in the Western States. Such conditions favor use of smoke management plans to match burning operations with favorable smoke dispersion weather. Thus, prescribed burning can generally be planned to avoid stagnant air conditions.

Regulatory effects of wildland smoke on biological organisms have received scant attention. But recent investigations (Parmeter and Uhrenholdt, 1975) indicated smoke might have important ecological implications:

--Surfaces exposed to smoke were found unsuitable for the germination of spores of several kinds of fungi.

--The mycelial growth of a damping-off fungus was inhibited on surfaces previously exposed to wood smoke, and direct exposure of the mycelium to smoke arrested growth.

1/Since impacts are similar for prescribed fire use in the presuppression and prescribed burning portions of the BLM's fire program, they will be discussed here to avoid later duplication.

--Smoked portions of pine stems showed marked changes in numbers and kinds of microorganisms that could grow on them compared with unsmoked controls.

Vegetation

Major changes are occurring in many vegetation types because of the general reduction of acres burned in recent years. The reduction in burned area can be attributed partly to improved detection, preattack planning, and prevention efforts. However, since these improved efficiencies are actually realized during the suppression actions, impacts related to reduction in size of areas burned will be covered in the suppression section. This approach will minimize the repetition of similar impacts.

An additional impact is the removal of vegetation during the construction of detection facilities, access roads, guard stations, firebreaks, fuelbreaks, and helispots. There is also the corollary impact of the visual scene as landscapes are modified by presuppression measures.

The prevention measure of fuels management is recognized as a major solution to conflagrations. Fuel management involves the alteration of living and dead vegetation to enhance man's ability to contain conflagrations. The potential effectiveness of the fuel management concept has been summarized (Martin and Brackebusch, 1974):

> "An effective program of forest fuels management is our most promising long range fire management tool. Fuels accumulate in our forests but are often disturbed by man. Reduction of the accumulations historically has been through fire--sometimes gentle and frequent where accumulations were low, conflagrations where accumulations of fuel were heavy. We have attempted, in the past, to prevent conflagrations by building efficient and effective fire control organizations. Effectiveness of these organizations is evident from fuel accumulation, so that we presently have powerful fires that overwhelm our firefighting organizations. Since manipulation of weather or climate is beyond man's present capability, our greatest opportunity for fire management and conflagration prevention must be through fuel management.

"By managing forest fuels, we work within the natural system in our forests rather than attempting to buck it through the brute strength of fire control organzations. Fire is a natural component of the forest system. Use of prescribed fire may accomplish many silvicultural, ecological, aesthetic or sociological purposes better than either a wildfire, in its sporadic way, or manual-machine manipulation. Properly used, fire removes the smaller fuel components. Improved utilization will remove larger components. Utilization, fire and other treatments all have a place in reducing residue fuels.

"There are two main avenues through which we might alleviate our residue-fuel problems:

"1. Fire considerations (as well as other environmental effects of forest residue) must be taken into account with the initial considerations for management of a forest area.

(a) Models are being developed for management decisions involving realistic evaluations of fire potentials.

(b) Appropriate actions can be taken to reduce fuel loadings in patterns designed to reduce potential wildfire spread and damage.

(c) Personnel qualified to evaluate objectively fire potential and develop plans for fuels management can be employed.

"2. Improved utilization practices must be used.

Management plans should be modified to require maximum removal of material."

Fuel management practices are most often carried out on national resource lands in coniferous forests, in the chaparral type, and along rights-of-way. Fuel hazard reduction practices include: roadside cleanup, prescribed burning for slash disposal and natural fuels, removal of some dead snags, minimizing

horizontal and vertical fuel continuity through pruning, thinning and elimination of undergrowth, firebreaks, fuelbreaks, and closer utilization of logging residues. Such practices must be prescribed in such a manner as to complement the requirements of the ecosystems being managed (i.e., consideration given to impacts on nutrient cycling, energy flow, food chains, habitat needs, etc.).

Presuppression-prevention practices in fragile tundra environment can be very severe wherever the insultating mantle of tundra vegetation is destroyed or disturbed. The placing of buildings or access roads without proper regard to the underlying permafrost will cause a sinking and slipping of the underlying soil.

Recent studies, primarily in regard to the Alaska pipeline to Prudhoe Bay, have shown such facilities as roads can be built in this biome but certain conditions must be met so the underlying permafrost is protected. The location of firelines, camps, and the like, must also be considered or permanent harm results.

Beneficial impacts of fuel management can:

--Reduce the number of fires,

--Reduce the frequency of conflagrations through reduction of large concentrations of hazardous fuels with firebreaks and fuelbreaks,

--Reduce spot fire problems through elimination of some snags,

--Inhibit damaging insect outbreaks,

--Provide a mineral seedbed for the establishment of seedlings by slash burning,

--By slash burning, stimulate browse species for wildlife.

Adverse impacts of fuel management can include:

--Heavy equipment used can result in tree injuries such as skinned bark and root damage.

--Logging slash treatments consisting of chipping, chopping, chaining, compacting, or rolling may reduce the fire hazard, but adversely affect tree regeneration and site productivity. Buildup of a deep mulch or organic layer, could choke out vegetation and cause a bacteria buildup that ties up available nitrogen.

--Slash fires can damage or kill trees that land managers had not planned to burn.

--Complete removal of forest residues (clean logging) may deplete the storehouse of available nutrients.

Wildlife

TERRESTRIAL

The principal presuppression-prevention impacts on wildlife are due to hazard (fuel) reduction, construction of facilities, and human presence.

Hazard reduction consists of removal of fuel in the form of slash, underbrush, dead snags, and the clearing of all vegetation in strips for firebreaks, accomplished by mechanical or chemical means or by fire.

Favorable impacts are those habitat changes resulting in the opening up of dense brush or slash, improving animal movement and access to water; firebreaks and fuelbreaks providing travel lanes in forests and variety in life forms (e.g., grass openings in forests); and, disturbed areas producing new or rejuvenated high-quality forage. In some situations firebreaks become greenbels and are pastured. However, fuel reduction operations can also cause direct losses to wildlife--particularly to nests and young animals. This occurs through ground level disturbance and through snag removal. Snags are very important to many mammals and birds for nesting and denning, perching, or resting and sleeping. Indirect impacts are due to habitat destruction by power equipment, herbicides, or burning. This loss of food and cover is generally temporary and localized.

Construction of facilities, such as roads and trails, lookouts, and other presuppression-prevention building projects, produces much the same impacts on habitat, good and bad, as

discussed for hazard reduction. All of these operations of detection, prevention, and construction, in all biomes, cause temporary or intermittent disturbance to wildlife due to human presence. This includes the general activity of work crews and patrols, and the noise of machinery. Over a longer period, the provision of access encourages an influx of hunters and other recreationists.

AQUATIC

Hazard reduction actions such as slash burning and herbicide spraying can adversely impact shoreline vegetation of lakes and streams. Removal of streamside cover and canopy allows streambank erosion with subsequent stream siltation and increased solar radiation which could cause water temperatures to rise to a critical level for fish (Kopperdahl, et al., 1971).

Fire prevention is essential for the maintenance of a stable productive aquatic habitat. Little is known about beneficial effects of burning streamside vegetation on aquatic habitat.

Domestic Animials

Livestock will use firebreaks and access roads built to lookouts and guard stations to gain access into previously ungrazed or lightly grazed areas. This will have a beneficial impact on the animals because additional forage will be available.

Better livestock distribution would result, which could reduce heavy grazing use in other areas. However, conflicts with other resource uses can occur in the areas made available to livestock by the firebreaks and roads. These conflicts could involve such things as wildlife, wild horses and burros, recreation, and watershed.

Hazard reduction by burning could have an adverse effect of temporarily reducing the grazing capacity immediately after the fire. Duration of this effect depends on the volume and size of fuels, season of burning, and specific site factors affecting the reestablishment and growth of vegetation. However, the long-term impacts would be beneficial in that the amount and quality of available forage would increase. Garrison and Smith (1974) pointed out the burning of slash reduces the impact of woody debris as an obstacle to grazing animals and influences composition of the vegetation that occupies the site in the process of secondary succession.

Another beneficial impact of hazard reduction would be the reduction of the risk of a large destructive fire that could spread into valuable grazing areas and do considerable damage to forage resources.

Wild Horses and Burros

The impacts of the presuppression-prevention program on wild horses and burros are minor. There may be some disturbance by detection aircraft, although detection flights are normally made at altitudes that would not frighten the animals.

The construction activities involved in building firebreaks and roads to lookouts or guard stations in areas inhabited by wild horses and burros may frighten the animals. The increased access provided by the roads and firebreaks will afford the public with a better opportunity to observe wild horses and burros. However, the increased presence of humans may force the animals into more remote areas.

Better wild horse and burro distribution would result, which could reduce heavy grazing use in other areas. However, conflicts with other resource users can occur in new available areas.

Hazard reduction would have a short-term effect of reduced forage capacity. However, the long-term impact would be beneficial since the amount and quality of forage would increase.

Human Interest Values

SOCIOLOGICAL

All sociological aspects and land use patterns must be considered in analyzing potential environmental impacts of the fire management program.

All phases of fire operations affect, to some degree, recreation uses and values. Impacts, where they do occur, will be most significant in: areas of intensive recreational use, areas of unique or rare resources, and areas of concentrations of resources which make up high recreational potential.

In recent years BLM lands have become very attractive to the public for recreational activities including offroad vehicle use, rockhounding, and weekend camping. Access provided by presuppression-prevention activity can increase accessibility.

The development of access roads and trails during presuppression-prevention can also result in a hazardous situation for the general public. Off-road vehicle enthusiasts operating low standard, nonmaintained roads and trails often encounter washouts and slides that can result in injury or death.

New roads resulting from presuppression-prevention would undoubtedly result in a further demand for urban-character land uses. Uncontrolled expansion could result in strip development along roadsides with few social or aesthetic attributes and a general inefficiency in land use.

Presuppression-prevention activities impairing or destroying natural areas could have a significant adverse impact, if those areas have value for scientific or educational purposes.

All phases of presuppression-prevention fire management operations with the possible exception of airborne detection would have adverse impacts on wilderness areas. But even the noise from detection aircraft can be objectionable to recreationists. Programs using a minimum of support measures would have the least impact on wilderness values. The existence of permanent roads would negate wilderness status of the land; vegetation manipulation by artificial means and the construction of facilities would also decrease wilderness values.

Presuppression-prevention activities can take a small amount of agricultural and forest land out of production, causing a minor impact on local economies.

The potential for adverse effects to human health and loss of life must be considered on all projects using heavy equipment and hand-held power tools. Some beneficial impacts could also result from presuppression-prevention operations. Extensive recreation uses, particularly hunting, may benefit from improved access and improved habitat through fire operations. Fire access roads, if usable for timber harvest, could later benefit timber hauling.

GEOLOGICAL AND CULTURAL RESOURCES

In this portion of the report all geological, archeological, historical, and cultural values have been combined under the broad heading of "cultural resources" to avoid repetition.

Geological values are susceptible to alteration and destruction as the result of presuppression-prevention fire management practices that can destroy or impair their value as human interest subjects. Power equipment and other earth-moving equipment used in the vicinity of delicate geological features, such as cave formations or erosional arches, can destroy or impair their interpretive value. Structures such as lookouts placed in close proximity to geological features tend to detract from their value for viewing and interpretive purposes.

Some geological phenomena are susceptible to collection and removal even though such actions are illegal or limited as in the case of fossils or petrified wood. Increased accessibility as a result of new roads and trails and other presuppression-prevention activities could contribute to removal or vandalism.

Archeological and historical sites are most valuable to the scientist when they are undisturbed. In the past, roads and trails constructed on Federal lands have damaged or destroyed archeological and historical remains. This is of potential impact in practically all areas from presuppression-prevention activities involving excavation or soil disturbance. An adverse and beneficial impact may result from new access. It can result in vandalism, illegal looting of prehistoric and historic sites for souvenirs; it can also open such sites for public enjoyment.

New roads and trails and other disturbances on or near sites can destroy or damage the prehistoric or historic scene by introducing modern elements foreign to the period, thus detracting from the understanding and feeling the visitor obtains. Use of power equipment close to caves, walled structures and on top of sites can cause damage by shaking them down or by compacting the soil, disturbing the stratigraphy and crushing artifacts within the soil. Ground disturbance activities at some distance from archeological or historical sites can trigger erosion which may either destroy the site or cover it with eroded debris. Indian campsites and "tipi" rings are frequently destroyed by offroad vehicle travel or any earthmoving activities.

Many archeological sites in the taiga and tundra are frozen, preserving the prehistoric materials in excellent condition, but also providing sites highly susceptible to erosion if the surface is disturbed and exposed to melting. Many of the sites are on gravel bars along streams, prime sources of material for road building and other construction activities.

In the coniferous forest there are many abandoned settlements resulting from the gold rushes and land settlement attempts. Fire access roads in the vicinity of these structures could result in vandalism and degradation of the historical resource.

Sometimes presuppression-prevention practices can help discover potential archeological sites, such as caves covered by heavy brush, without any adverse effects on the site itself (Carlsbad Current Argus, 1974). New roads may also improve initial attack capability thereby protecting archeological and historical values.

AESTHETICS

Aesthetic values are derived from how people perceive the environment and are regulated by form, shape, color, texture, composition, lines, etc. Actions producing a visible change in any of these elements of the natural environment can cause pleasant or adverse human reaction dependent on the attitudes and values of the individual.

There are three ways that presuppression-prevention activities can alter the landscape:

--The vegetation can be removed or changed.

--The soil can be moved.

--A structure can be placed on the landscape.

The degree to which any of these actions upsets the natural harmony of the basic components determines how great an effect the action has on the overall landscape and whether that effect is a negative impact or improves the visual environment.

While the landscape character is subject to change brought about by presuppression-prevention practices, areas that are still in near natural condition stand to suffer the greatest impacts to the visual environment. However, areas where the landscape has been altered for agricultural or developmental purposes may have taken on a new character which is pleasing to look at and might be disrupted as much as a natural area.

In hazard-reduction projects, manipulation of vegetation and the secondary adverse impacts on soil creates a visual change that can be disturbing to those familiar with a particular landscape to a point where they consider any change in a negative manner. Regardless of the technique used in site preparation, there is a period when the project area is freshly disturbed and man's activities are clearly evident. The degree of this degradation of scenic quality varies sharply with site conditions and the sensitivity of the method of brush removal.

This impact could be shortlived in the grassland, but in the desert or tundra it can be a permanent scar.

The gentle slopes of the grassland require less movement of soil for road and facility construction than many other biomes, resulting in smaller scars on the landscape. However, it is often possible to see considerable distances in the grasslands, making surface disturbance quite obvious over a wide area.

Desert landforms are steep and high in many areas; many of the operations involving movement of earth could create a scar visible for great distances. Vegetation in the cold desert takes a long time to recover to its natural condition; in the hot desert, recovery involves even longer periods of time. Lines created by roads, trails, firelines and vegetative manipulation will be visible in the desert for a great length of time. In many areas of the desert, the color of the soil and rock is the result of long years of weathering and chemical interactions. When this surface color is disturbed, it is virtually impossible to restore and can take hundreds of years to recover naturally.

In densely vegetated woodland-bushland communities impacts can be more obvious. However, the density of the vegetation might also reduce the visual impact by restricting the viewing area.

Because of the steep terrain and the high relief profile in the coniferous forest, firelines and roads are often visible for extremely long distances.

There are also beneficial impacts of the presuppression-prevention activity on the visual environment. Sometimes access roads open up impressive scenic vistas. Vegetative manipulation can result in forage production, attracting wildlife which can be viewed by the general public.

When planning hazard-reduction projects in extensive brushfields, the potential exists for increasing visual variety in the landscape. This is a positive step toward enhancing scenic quality. Extensive brushlands are visually sterile with little variety in color or texture of the vegetation. The sight of a stand of young trees growing on a mountainside is a very pleasing experience to most people. Flowering plants often add diversity of color in recently cutover areas and cleared brushfields. Fall colors of many plants are striking against the green of the trees.

Fire detection activities of the presuppression program, whether aircraft or lookouts, have minimal impact on the visual environment.

OTHER

A complementary benefit of impact of the detection practice concerns human rescue. The article that appeared in the Rocky Mountain News, Denver, Colorado, August 1, 1975, demonstrates this point and is included below.

"Ten rescued in wilderness area

"Ten persons, including a 10-month-old baby, were rescued Friday after being stranded for three days in wilderness area near the Utah-Colorado border.

"They were rescued by a Bureau of Land Management helicopter crew responding to the sighting of one of eight fires set by the group to attract attention, according to BLM official Gus Juarez.

"The group had survived three days on bacon, one can of pop, water found in cracks and two rabbits they shot. They were identified as Robert and Sharon Carter, Frank Stevenson, Sandra Harbin and six children ranging in age from 2 to 8. Officers said all were apparently from Grand Junction.

"The sheriff's office said the group became stranded Tuesday when the transmission of their 1962 model car was damaged by rocks on a sheep trail in the Pinon Mesa area 15 miles southeast of Cisco, Utah.

"The fires were set Thursday night and spotted early Friday by Howard Mann and Cy Hubbard of Gateway.

"The members of the group were in good condition but beginning to show signs of exposure, the sheriff's office said."

IMPACTS FROM SUPPRESSION PRACTICES

Impacts from fire suppression activities can arise in several ways, one is the direct impact of suppression practices (e.g., line construction, retardant drops, burning out and backfiring, cutting trees along firelines or at the helispots, and human presence) on various components of ecosystems. Another form of impact is more subtle. Successful fire suppression actions can exclude fires from areas where it was formerly common, causing indirect but major impacts on ecosystems over time (e.g., loss of species diversity, fuel accumulations). Suppression actions also protect society's investments in natural resources to produce certain goods and services.

Soil and Water

A direct adverse impact of fire suppression on soil properties is erosion due to fireline construction. Fireline construction by bulldozers, especially in northern or high altitude environments, can cause more damage than the fire in terms of soil erosion (Bolstad, 1971; Lotspeich, et al., 1970). In studying the 1967 Chicken Fire in Alaska, they found few signs of erosion in actual burned areas but drastic erosion and degradation along fire control lines and bulldozer trails.

Fire may have a detrimental effect on forest soils. Relating suppression actions to impacts on soil properties is a complex issue and considerations must be given to landforms, soil conditions, fire intensities, revegetation, and meteorological conditions following fires. Generally, the indirect impact of excluding fires from watersheds through suppression actions will be favorable when severe fires could lead to accelerated erosion rates, increased sedimentation in water bodies, and land slumps. Some of these impacts also could be initiated through the use of fire in fighting fire (i.e., backfiring or burning-out operations to achieve black [safer] firelines). But this impact is almost always minimal when compared to the acres burned by the uncontrolled wildfire.

It must always be recognized the longer fire is excluded from some wildland environments, the greater is the potential for more severe fires in the future. Philpot (1974) postulated that attempts at fire exclusion through suppression actions in southern California chaparral could result in watershed damage and downstream effects remaining high or increasing because the average size of large fires would increase.

Fire exclusion through suppression actions results in another, potentially adverse, impact on nutrient cycling on some sites. As the organic layer increases in the absence of fire, nutrients become unavailable to plants. Using the data of Cole, et al. (1967), Behan (1970) hypothesized that critical amounts of nutrients may become tied up in the forest floor; and that mineral absorption by plants might be restricted due to an eventual drain on the soil nutrient reservoir.

Geographical area adds further complexity to the assessment of indirect impacts of suppression actions on soils and water. Lutz (1956) indicated erosion on burned areas in Alaska was surprisingly small despite the fact soil properties would lead one to conclude they were easily eroded. Scotter (1964) reported erosion following forest fires in northern Saskatchewan was not serious; several years after a burn he found increased infiltration rates on burned soils versus unburned soils and felt this would reduce threat of erosion. These infiltration data are in contrast to that of other workers in temperate zones where infiltration rates on burned areas have been lower than on unburned areas (Beaton 1959; Burns, 1952; Kittredge, 1938).

It is from fires that must be fought with the usual suppression tactics that the greatest impacts on water may be expected. These fires are on an average more destructive and the control activities more critical in physical and chemical disturbance. Greater runoff and soil movement may occur as a result with greater soil compaction on roads, firelines, and fire campsites. Any use of fire retardants will add fertilizer elements that may react beneficially or destructively in different situations. Petrochemicals are a potential source of water pollution.

When fire retardants (diammonium phosphates and ammonium sulphates) reach lakes and streams in heavy concentrations, unacceptably high levels of nitrogen and phosphorus nutrients can occur in streams and lakes (Lotspeich and Mueller, 1971).

Eutrophication is a more serious phenomenon in lakes than in streams, because lakes act as a sink collecting phosphates, and high levels of this nutrient could change lake ecosystems.

When extensive areas are cleared of water-using vegetation, a condition of soil saturation can arise causing landslides where soils are susceptible to slippage (Rothacher and Lopinshinsky, 1974).

Air

Many wildfires, because of their size, timing, accompanying windy weather, and combination of moist, dry, green, and dead fuels burn inefficiently consuming tremendous amounts of fuel and producing great quantities of smoke emissions. In comparison, the emissions from power equipment used in line construction, the aerial and ground transportation vehicles, the assorted grenades, torches, and fuses used for burning out, the dust produced along the roads, firelines, airports, and helispots, and the cooking, garbage disposal, and heating fires at fire camps are very insignificant and wil not be discussed further here. Drift of spray from currently used retardants (discussed in part I) is local and primarily has fertilizer effects. The primary air quality effect of suppression actions is in stopping the emissions of the wildfire, also long-term effects due to fuel accumulation. Smoke produced by burning-out operations essential to control of the fire is indistinguishable from the fire smoke and should be considered part thereof.

Vegetation

The impacts of suppressing fires can be summarized as mostly beneficial where it is desirable to protect investments in natural resources. However, the suppression action can have short-term and long-term adverse effects on vegetation.

Beneficial impacts of the fire suppression program are:

--Protecting natural resources being managed to produce forage and fiber (Ill-timed fires can substantially impair the capability of grasslands and forests to produce grazing and wood products.);

--Ensuring a protective mantle of vegetation on watersheds;

--Maintaining conditions favorable to fire-sensitive species;

--Perpetuating later successional stages, or climax vegetation.

Short-term adverse impacts of the fire suppression activity are:

--Fireline construction with heavy equipment can have serious and direct consequences; one effect is the decline of site productivity as the soil mantle is drastically disturbed.

--The construction of fire camps and helispots can cause adverse impacts on vegetation; but these effects are usually more localized than the effects of fireline construction.

Long-term adverse impacts are:

--Fuel accumulations occur, resulting in larger and more damaging fires.

--Nutrients are tied up in organic residues.

--Loss-of-life-form diversity and species diversity occur as fire suppression reduces acreage burned (i.e., shrubs invade grasslands, shrubs decline in forests, herbaceous vegetation declines in woodlands and forests).

--Fire-dependent vegetation is not as abundant on landscape. Some of the most commercially important tree species are postfire species (often dependent on fire).

GRASSLANDS

The impacts from fire suppression practices in all grassland types are quite similar. Grasslands, in the absence of fire, are invaded by woody shrub species to the detriment of the range productivity. Wright (1969, 1971, 1972a, 1972b) and his associates have studied this effect in detail in western Texas. In some instances the productivity has been so lowered that the ranges are uneconomic for livestock production.

DESERTS

Adverse impacts from fire suppression practices in both the hot and cold deserts have occurred largely by the building of firebreaks, access roads, movement of mechanical equipment and men, and other normal disturbances by such suppression activities. The driest portions of the desert, both hot and cold, are the most fragile and here the recovery of the vegetation is exceedingly slow. In regions of higher precipitation, where the true desert grasslands occur, such disturbances are not quite so damaging. Overgrazing and fire exclusion due to suppression actions have caused the invasion of many species of woody shrub and cacti to the detriment of both livestock and wildlife produciton.

Humphrey (1937, 1949, 1958, 1963), Cable (1967, 1972) and others for over a period of more than a quarter of a century have considered fire of prime importance in the management of the desert grasslands of Arizona and New Mexico; in fact many of these desert grasslands are termed "fire-climax" grasslands. Following wet years, particularly wet summers succeeded by wet winters, fires can also be considered a part of certain saguaro cactus areas where even in these relatively dry regions invasion by woody shrubs can occur. Fires can occur where reduced grazing pressure allows dry grasses to accumulate. As in more temperate grasslands, fire often retards and/or prohibits the invasion of woody species and cacti.

The cold desert grasslands of the plateaus of northern Arizona and New Mexico to the basins of the northwest into Canada are not as fragile. Studies in the more northern basins have not been as complete as in the Southwest. However, these also show the invasion of shrub species in the absence of fire, except possibly in some local areas where the grazing pressure or other factors inhibits such invasion (Daubenmire, 1959).

Thus in both the hot and cold desert, fire suppression often brings about a succession from grasses to more shrubby-type vegetation. Before the advent of heavy grazing by livestock these grasslands were characterized by a mosaic of grasses, forbs, and shrub species. Fire suppression and overgrazing have altered this mosaic in many respects. This impact is perhaps much more serious than that caused by the mechanical disturbance mentioned earlier.

WOODLAND-BUSHLAND

For our purposes the woodland-bushland biome can be divided into three major subdivisions that vary in their fire relationships from the oak-chaparral (one of the most fire-adopted plant communities in the world) to the pinon-juniper, the plant species of which are fire sensitive in many respects. The oak-woodland area is halfway between the other two types in its fire relationships. These three divisions invade the grasslands in lower elevations and the forests in the higher zones.

Oak-Chaparral. Fire suppression practices in this type have produced major impacts and some investigators insist the present devastating wildfires are caused by over protection from fire. Philpot (1974) reported the chaparral becomes more and more flammable as it matures. "As fire suppression becomes more effective, the number of large fires should decrease but the size of large fires should increase," and "Unless fire policy is changed on chaparral lands, there seems to be little evidence that the recent history of large fire will not be repeated." The resulting erosion and other effects of these devastating fires has been well documented by the previously listed sources.

Much damage to the environment has been done also by the direct effects of fighting fires on the unstable steep slopes where this vegetation occurs. The erosion effects in some of these areas in southern California are so large they have been photographed from 5,000 feet as large longitudinal gullies (Komarek, personal observation). In some regions the devastation by the firefighting practices of the past have been more evident than the effects from the fires themselves.

Oak-Woodland. The impact from suppression practices on oak-woodland areas vary because of differences in such things as soil types, slope, and drainage patterns. Because some of this type of vegetation occurs on relatively unstable soils, the damage by mechanical equipment in actual suppression of fires can be considerable. Perhaps the greatest impact such practices have is in the indirect effect of excluding fire from what is essentially a fire environment. Under fire suppression and protection the oak-woodlands become choked up with a heavy undergrowth of brush. The famous oak-parkland and grasslands disappear, resulting in highly flammable conditions with heavy fuel loads. Even as an open parkland, the area is flammable because of the grasses, but fires are much easier to control in the finer grass fuels and the effect on the soil and related qualities of the fire are not severe.

Pinon-Juniper. Fire exclusion may cause the invasion of pinon and juniper into grasslands, lessening grassland productivity. The disturbance caused by mechanical equipment on these more or less arid environments coupled with grazing is at times quite severe. At the same time, it should be pointed out, the overburning of such habitats coupled with overgrazing or grazing too early on the burn can also be devastating to the grassland and to the soil. Many such pinon-juniper lands have been chained in recent years and managed as grasslands thereafter.

CONIFER FORESTS

A high percentage of the vegetation in the coniferous biome is at one stage or another of succession following past fires. Climax, or near climax, forest stands that have escaped fire for several centuries are rarely found in the biome, indicating the significant role fire has played in producing vegetation mosaics on the landscape. But even the absence of roads in many coniferous forests has not prevented the use of sophisticated technologies of fire detection and fire control, technologies including patrol planes, some equipped with infrared scanners,

and airplanes and helicopters that can deliver firefighters, equipment, and fire retarding chemicals to even the most remote fires.

The effective reduction of fire on landscapes that historically were influenced by periodic fires will have a detectable and measurable modifying influence. The impacts of advanced fire control systems are least pronounced in sparsely vegetated high elevation forests and most apparent at lower elevations where mosaics of different age classes, species, and life forms are gradually becoming less discernible. Loucks (1970) observed that disturbances such as fire tend to recycle the system and maintain a periodic wave of peak diversity. He concluded that any modifications of the system that would eliminate random disturbances and recycling would be detrimental to the system. Some of the specific detrimental impacts of fire suppression on vegetation in the coniferous biome include:

--The total number of species will decline. A 65-percent decrease in species of plants and animals occurred following closure of the canopy in some lodgepole pine forests (Taylor, 1973).

--Fire serves as a decomposition agent in the cool environment of the coniferous biome (Habeck and Mutch, 1973). In the absence of fire, organic material accumulates, contributing to extensive and high intensity fires (Roe, et al., 1972; Wilson and Dell, 1971).

--Fire suppression has allowed vegetation under the forest canopy to become more dense (Marshall, 1963; Biswell and Weaver, 1968), enhancing horizontal and vertical continuity of fuel. This distribution of fuel increases the potential for crown fires (Kallander, 1969).

--Fire suppression has resulted in the virtual elimination of the light surface fire which historically maintained some forest types in an open grown condition (Vankat, 1970).

--It has been suggested that plant species that have survived fires for thousands of years have selected not only survival mechanisms, but also inherent flammable properties contributing to the perpetuation of fire-dependent plant communities (Mutch, 1970). Thus, fire-dependent plant

communities may burn more readily than non-fire-dependent communities because natural selection has favored development of characteristics that make them more flammable. These highly flammable properties of some species can.be detrimental to a community under a policy of fire suppression, because the accumulation of hazardous fuels over a long period leads to destructive fires.

--Aspen becomes decadent and declines as taller conifers shade it out (Houston, 1973).

--Shrubs in the forest generally decline when fires are suppressed due to shading effects from taller trees, lack of mositure or nutrients, and lack of fire required to germinate seeds (Agee, 1974).

--The amount of herbaceous vegetation decreases in the forest as basal area, crown cover, or amount of litter from the overstory increases, due to competition for light, nutrients, water, or inhibitory effects of chemicals in the litter (Cassady, 1951; Clary and Ffolliott, 1966; Jameson 1966).

--Without fire the boreal forest would become more and more homogeneous. For example, the long-lived white spruce gradually replaces pine, aspen, balsam poplar, and birch on well-drained sites (Rowe and Scotter, 1973).

--The energy buildup in the form of accumulated forest litter and some brush species that are favored by lack of fires is causing the fire control job to become more difficult and costly (Loope and Gruell, 1973).

The impact of suppression practices can be very destructive in Alaska. Lotspeich and Mueller (1971) said "Findings from a study of fire effects on the aquatic environment lead to the conclusion that the fire had fewer deleterious effects than did activities from fighting the fire--improper locating of 'cat' lines as an example," and DeLeonardis (1971) in a study "Effects of Fire and Fire Control Methods in Interior Alaska" said:

"The objective of fireline construction was to remove all burnable material from the path of the fire.

insulating vegetative layer which led to the very rapid melting of the permafrost. The berms thrown up on either side of the catline created effective artificial

channels. To compound the problem further, the lines were tied directly to the closet body of water for more effective construction.

"The conditions were ideal for an erosion problem resulting in siltation of streams. That is exactly what happened. In some areas underlain by deep silt permafrost soils, <u>gullies 20-30 feet were created in just two years</u>..." (underlining for emphasis by Komarek).

TUNDRA

The effects of fireline construction on tundra are essentially the same as on taiga permafrost. But marks left on the tundra will be visible for hundreds of years, while many lines constructed in the taiga may be healed in five to ten years.

WILDLIFE

TERRESTRIAL

Fire suppression or firefighting practices are chiefly fireline construction and aerial attack. These consist of use of machinery or handtools, retardant application by aircraft, and the setting of backfires. The impacts parallel those of presuppression, but with an urgent need of application and little opportunity for onsite planning or nonfire considerations. The enhancement or depreciation of wildlife food and cover due to fireline construction probably will be secondary to those due to the fire in most situations and biomes. Likewise, the disturbance by the aircraft, the fire crews and their work and camps, and any burnouts and backfires, would produce similar impacts to those of hazard reduction and firebreak construction described under presuppression.

The major impact of fire suppression practices lies in the long range, ecological consequences of permitting the vegetation to succeed towards large expanses of mature homogenous types.

The policy of suppressing all fires was based on the idea that fires were an unnatural presence. One purpose usually given was to conserve wildlife. Much of primitive America supported successional communities maintained by fire. Without fire, vegetation trends toward uniformity, resulting in fewer wildlife species than would be present with a mosaic of vegetation types and ages (Agee, 1974).

R. Komarek (1963) has summarized this well-known concept, stating the management of wildlife basically is the management of vegetation, because wildlife depends on vegetation for survival. Wild animal populations are mobile and can move to areas more suitable to their environmental needs, but when ecological succession destroys their habitat over a wide enough area, they perish. Land management policies for wildlife must recognize the instability of the habitat and provide measures to maintain and control vegetation patterns. Fire was at least one of the prime ecological factors responsible for the original varied mantle of vegetation.

The earliest and best known investigation of the effects of succession on wildlife conducted in this country was in the Southeast. There, annual burning in the pine forests prevents the grass understory from becoming a hardwood jungle, and holds plant succession at the most productive stage for bobwhite quail and other uses (Stoddard, 1931 and E. Komarek, 1971).

Without fire most native grasslands are rapidly colonized by woody species. Fire suppression and the absence of deliberate use of fire to control vegetational succession has done untold damage to prairie wildlife. Historically, prairie chickens and sharptail grouse were abundant on the priarie where fires were frequent (Kirsch and Kruse, 1972).

Ward (1968) at Delta marsh, found ducks and muskrats increased following fire. Unless the large marshes of Manitoba, managed for waterfowl, include use of fire they will deteriorate and may even cease to be marshes.

In the desert grassland where woody species invade with fire control (Humphrey, 1963), a study by Soutiere and Bolen (1972) found that current-year burns were favored over nonburned sites by nesting mourning doves.

Klebenow (1972) reported sage grouse on the cold desert were quick to occupy a burn. Moderate burning of dense sagebrush to open up small acreages in homogenous stands is beneficial to wildlife.

A dense continuous mature forest of coastal Douglas fir contains a limited number of wildlife species. Lyon (1969) reported recovery of burned forests coincided with game population reductions. In the northwest coastal sub-biome, fire changes the successional pattern of vegetation and alters other components of the ecosystem, including the animals. Normally low populations increase rapidly following fire which produces earlier successional stages. These effects last 10 to 25 years until the canopy closes (Redfield, et al., 1970).

Various authors (Viereck, 1973; Scotter, 1970; Spencer and Hakala, 1964; Edwards, 1954; and others) have discussed the impacts of fire on wildlife in the taiga-tundra biome. Climax forest animals such as marten and its prey species, the red squirrel, are removed when the forest burns. Moose and beaver prosper during early stages of forest succession; the effects last 20 years or longer. Regarding caribou, some reports (Scotter, 1964, 1970; Buckley, 1958; Lutz, 1956; Edwards, 1954) state lichens are a principal winter food, they are highly flammable and recovery is extremely slow--perhaps 50 to 100 years, and therefore fires on the winter ranges are detrimental. Other authors, as Skoog (1968) and Viereck (1973), agree fire destroys the winter range, but the topography and natural fire barriers in the Alaskan interior prevent extensive continuous burns. Also, caribou exist on many plants besides lichens.

In addition, Oberle (1969) said many animals depend on lightning fires to maintain a constant cycle of vegetation types for food and cover.

AQUATIC

Fire retardants in sufficient quantities are toxic to a variety of freshwater fish and a common freshwater crustacean (Gammarus). Basically, it is the ammonia content in the fire retardants that kills the aquatic animals. The younger life stages of fish and aquatic organisms appear to be more sensitive to retardants than the older, larger fish. Aquatic animal mortality is likely to occur when the retardant is delivered in large quantities directly into the water (Borovicka and Blahm, 1974).

Stream and lake shorelines should not be used as natural fire control lines unless fire cannot otherwise be controlled. Removal of vegetation along waterways may cause unstable soil conditions and siltation of lakes and streams. However, such natural features are used for control lines in Alaska. Burning up to water bodies in Alaska generally has not produced adverse impacts.

Construction of firelines and access roads can have adverse impacts on aquatic systems. Bachman (1958) observed significantly fewer invertebrates in Idaho streams following sedimentation from logging road construction.

Domestic Animals

There will be some disturbance of livestock by fire suppression forces. Noise created by heavy equipment, crews, and aircraft will cause livestock to move to areas away from the activity. There may be some weight loss to livestock as a result of this disturbance, especially if they are forced to travel longer distances from water.

During suppression activities livestock management facilities such as fences and water developments can be damaged by suppression crews and equipment. When fences are knocked down, livestock, primarily cattle and domestic horses, drift into the wrong management field or allotment and can mix with livestock owned by other ranchers. Livestock weight losses would occur, the amount depending on the difficulty involved in gathering and separating the animals and the distance that they had to be moved.

Wildfires can temporarily remove the vegetation in an allotment, forcing the livestock owner to remove his animals and find forage elsewhere. This creates an economic hardship on the livestock owner and can necessitate the sale of the animals if other grazing lands are not available.

Wildfires in the tundra biome in Alaska can have an especially serious impact on reindeer ranges by removing the lichens so necessary for reindeer survival. It takes many years for the lichens to return and, in the meantime, other suitable ranges must be found.

Suppression efforts often prevent destruction of valuable livestock forage by reducing the size of wildfires. The remaining forage is usually sufficient to take care of the animals or, if not, only partial removal of livestock may be necessary.

Wild Horses and Burros

The activities of suppression forces through the use of bulldozers, vehicles, crews, and, especially, low-flying aircraft will frighten wild horses and burros causing them to leave the fire area and seek refuge away from the disturbance. This can result in the animals being separated from their preferred foraging areas or waterholes.

However, this would be a temporary inconvenience rather than a serious adverse impact because the animals could return to their preferred area as soon as the fire was out and the suppression forces had left.

Suppression efforts can save wild horses and burros from injury or death as a result of being burned by a fire. However, the chances of the animals being burned are rather remote unless the fire would force them into a fence corner or trap them against an obstacle such as a cliff or vertical canyon.

In some cases valuable wild horse and burro grazing areas will be saved by suppression efforts. This is an especially beneficial impact if the forage saved is within a critical habitat area such as a winter range.

Also, overgrazing by wild horses and burros of adjacent ranges will be prevented or reduced by successional suppression efforts, holding forage losses to a minimum.

Human Interest Values

SOCIOLOGICAL

Large-scale fire suppression operations (bringing people and a surge of economic activity) may have temporary social and economic impacts in localized situations. The life of a fire varies greatly and may be from one day to several months.

Control results in a reduction of economic activity, leaving a vacuum in a local area.

Low population density characterizes most areas of major fires. Many of the small communities affected may not be prepared for the social and economic impacts, while others affected more regularly are better prepared.

In the tundra in areas inhabited by indigenous Americans, cultural differences are most apparent. The impact is largely unknown except that it could tend to accelerate transition to a non-native culture.

Fire suppression operations in certain areas containing unique resource concentrations could adversely affect the recreation-tourism industry.

It is possible to spill fairly large quantities of chemicals during various stages of transportation or application. As most fires are remote from population centers and agricultural crops, it is unlikely that spills could be confined to the locality. The exception is a spill into or very near a flowing stream. Fire camps and other suppression activities also can contaminate potable streams, and make the human users sick. Use of scarce petroleum products is another adverse impact.

Extensive uses such as livestock grazing may be adversely impacted by intensive activity such as tankers and heavy equipment. Historical or seasonal patterns of use may be disrupted, as grazing areas are temporarily eliminated. In areas that have experienced very high and continuing unemployment rates, if more effort were made to train and use local labor sources where possible in fire activities, the effect could be benefically significant on the local economy.

Secondary impacts of fire suppression include the potential loss of wildlife habitat, aesthetics, and species diversity. These losses could affect visitor enjoyment.

CULTURAL RESOURCES

Influxes of people associated with major suppression activities may impact the cultural lifestyles of the local residents. New dollars may be the greatest impact especially in areas of extremely low income. There may be a tendency for natives in some situations to imitate the introduced culture. However, all aspects of the cultural transition may not be apparent until later. There also can be positive impacts. Money, jobs, and temporary investments in the community can create a positive impact by tending to stabilize the economy.

In the juniper community area, the density of the juniper stands almost predetermines that some trees will be knocked over during fire operations. Roots tend to be intertwined with the masonry walls of the archeological and historical structures. Pushing the trees over tears up the site and churns the various levels of deposit. Pithouses may be hidden from normal view until the uprooting of the trees.

AESTHETICS

Roads and firelines all have impacts on the landscape during suppression access. There is a potential for long-term impact when vegetation and soil are disturbed (especially on tundra, taiga, and deserts). Placement of the fire camp, even though it is temporary, appears as an instrument upon the landscape. The introduction of human activities into a natural landscape brings with it associated litter and waste materials.

Noise levels associated with suppression may be high in a local area, but normally do not carry any great distance. Smells are generally minor, but can be an irritant in areas where inversions concentrate and hold offensive odors.

The control of fire by aerial application of chemicals can be a temporary detriment to the scenic quality of the area. Under emergency conditions it is difficult to leave islands of brush or trees. However, these islands are often a key item in blending the area to its natural surroundings.

IMPACTS FROM POSTSUPPRESSION PRACTICES

Postsuppression practices consist principally of: (1) rehabilation to mitigate fire suppression site disturbance caused by firelines, fire camps, etc., and (2) emergency post-fire treatment of the burn to restore the site and protect it from further damage; this includes seeding and planting, water runoff control and salvage logging in forest areas.

Soil

These rehabilitation practices are aimed at beneficially impacting burned areas. The renovation of firelines can involve the replacement of soil and components of the ground cover as well as seeding or planting to induce a vegetal cover. Burned area rehabilitation could depend totally upon natural recovery, but most likely will involve treatments of some extent on most

such areas. Snag felling on forest and woodland areas may be accomplished, or a cultural practice such as plowing might be completed to prepare the site for seeding or planting. These treatments may be accompanied by fertilizer application, but not all are normally used to stabilize each burned area and overcome the adverse effects of fire and firelines.

Water

Rehabilitation measures are completed to overcome these persisting effects of fire that are undesirable. The objective is to provide a protective vegetation cover to minimize soil movement and better regulate the amount and timing of runoff. The water resource will benefit in some degree from these treatments. Salvage logging can adversely impact streams by disturbing streambed and streambanks and by increasing water temperature, silt and logging debris. Herbicides and fertilizers are potential sources of water pollution.

Air

An inconsequential contribution to atmospheric impurities can be emitted as exhaust from power equipment and ground and aerial transportation vehicles and from disturbed dust and ash. A beneficial air quality impact of postsuppression activities is to reduce the potential of wind erosion and attendant dust from bare trails and burned areas by quickly establishing a plant cover.

Vegetation

Postsuppression measures affecting revegetation of suppression and/or wildfire damaged areas generally have beneficial impacts providing the practices used are designed to meet management objectives identified in the fire rehabilitation plan (see appendix F).

The natural recovery of desirable vegetation through a program of protection and management is always given first consideration in the rehabilitation of burned areas. However if it is determined that desirable vegetation was removed by the fire or undesirable vegetation will take over, the seeding or planting of adapted vegetation is essential to achieve resource management objectives.

Salvage logging, properly done, will reduce future fire hazards by eliminating some snags which are one of the primary points of ignition for wildfires. Also, the removal of weakened trees will reduce the habitat of insects. Site productivity can be reduced due to accelerated erosion, soil campaction, road construction, skid trails and landings, and slash accumulation.

In some desert areas the disturbance of the vegetation and soil by the actual suppression practices have created conditions that warrant postsuppression activities such as the seeding of firebreaks, campsites, and disturbed areas. Such a practice can stop excessive erosion either by wind or water. The seeding of firebreaks can also prohibit or a least lessen the possibilities of these being taken over by poisonous or otherwise objectionable plants.

Beneficial impacts of postsuppression programs on vegetation include:

- Recovery of vegetation through protection and management,

- Improvement of vegetative quality and quantity through seeding or planting,

- Hazard reduction--replacing high-hazard vegetation (such as cheat-grass) with fire-resistant species, reduction of snags through salvage logging (though complete removal would be detrimental to some forms of wildlife) ,

- Prevent invasion of noxious weeds,

- Reduction of disease and insect infestation in timber by salvage logging.

Adverse impacts on vegetation, primarily through salvage logging, can be:

Site productivity is reduced by construction of roads, skid trails, and landings causing soil compaction and erosion.

- Logging debris accumulation reduces wildlife mobility and causes stream pollution.

Wildlife

TERRESTRIAL

Fireline rehabilitation, consisting of replacing topsoil and litter components followed by seeding, and construction of water diversions to control erosion, benefit wildlife by restoring lost habitat. The new vegetation provides diversity, high quality food, and extensive edge habitat for wildlife.

Cleanup and seeding of fire camps and other disturbed areas similarly improve the habitat, and may even create new conditions attractive to species not present prior to the fire. The emergency seeding done within the burn is beneficial provided the preexisting, ground-level vegetation had been destroyed. Recovery of the native mixture of vegetation usually is preferable to artificial seeding; however, the time lag may be a determining factor if the erosion potential is high.

Following crown fire in the forest biome, salvage logging of merchantable trees proceeds on an emergency basis. In some cases operations continue for several years. Some wildfire species will quickly repopulate a burn, although it may take several years for their numbers to build up. Construction of roads and landings, equipment operation, vehicle access, tree cutting, log hauling and removal of snags all may produce adverse impacts on wildfire through disturbance or destruction of habitat and disturbance due to human presence.

In the California chaparral, wildfire rehabilitation usually consists of aerial seeding to grass and spraying with herbicide to control brush sprouts. Studies indicated fawn production and the total deer population is markedly increased in such areas (Dasmann, et al., 1967).

Some 13 to 15 years following an extensive crown fire in the pinon-juniper woodland of Arizona, dense stands of seeded grasses were intensively used by deer up to one-half mile from live woodland cover. Use was proportionately greater on the burn during a severe winter (McCulloch, 1969).

AQUATIC

Postsuppression reseeding of the watershed with grasses and forbs and the planting of trees and shrubs along stream banks will provide interim and long-term protection of aquatic habitat and stream water quality.

Water control structures such as detention dams, dikes, and water diversion dams are valuable aids to prevent silt and sediment from washing into flowing streams and degrading aquatic habitat.

Salvage logging should follow accepted logging procedures to protect streams by avoiding logging in close proximity to streams or crossing streams with heavy equipment or skidding logs through or near a stream.

Domestic Animals

Fireline rehabilitation has some beneficial impacts on livestock. Benefits are realized when the native vegetation removed during line construction is replaced. This also prevents the invasion of undesirable plants.

In steep terrain, the stabilization of fire lines by erosion prevention measures such as water bars and water diversion channels reduces erosion on adjacent lands, maintaining their forage production capabilities.

During the period when livestock are excluded from the rehabilitation area and have to graze in other parts of the allotment, competition for the remaining forage among all grazing animals will increase. Overgrazing and poor animal performance, such as weight losses, can occur.

The complete removal of livestock from an allotment can cause severe economic hardship on the owner of the livestock. Alternative sources of pasture may not be available and the livestock owner may be forced to buy expensive feed or sell his animals.

The adverse impacts on livestock are relatively short term (usually a year or less), having an effect only until the rehabilitation objectives have been obtained.

The beneficial impacts are long term, and the livestock grazing capacity of fire rehabilitation areas are usually greatly increased.

Crested wheatgrass seedings on burned ranges on national resource lands in the cold desert biome, especially in northern Nevada, southern Idaho, and eastern Oregon, have in many instances more than doubled the grazing capacity for livestock. Ranges requiring 10 to 15 acres to support an animal unit (one cow of five sheep) for one month prior to the fire required only one to five acres after the seeding.

Fences are constructed to protect burned areas. They also aid in achieving better vegetal and animal management.

Increased grazing capacity resulting from fire rehabilitation efforts provides opportunities for shifting of livestock use from adjacent overgrazed areas to the rehabilitated areas. This results in the improvement of resource conditions on the overgrazed areas as well as better plant and animal production on the rehabilitated area.

Wild Horses and Burros

The adverse impact of fireline rehabilitation are negligible as this work is done during and after the mop-up stages of the suppression activity. The beneficial impacts would be the same as for domestic livestock as discussed in the preceding section.

It may be necessary to exclude wild horses and burros from burned areas to ensure successful natural revegetation or the establishment of seedings. The animals would be driven to adjacent areas and the burned area fenced to prevent their return.

The physical act of moving the animals to a different area will frighten them and disrupt their normal behavior patterns. The protection fences around the burn may hinder seasonal migration or exclude an important water source from their use.

Also, when they are forced to graze in another area, competition for forage, water, and space will occur with other horses and burros, wildlife, and domestic livestock. This may result in overgrazing and watershed damage.

Most of the long-term impacts of postsuppression programs are beneficial to wild horses and burros. The conversion of dense brushland monotypes such as pinon-juniper to grassland through seeding, if necessary, greatly increases the quantity and quality of forage available to wild horses and burros.

In addition, the actual range or space available to the animals can be increased because the forage improvement within the rehabilitation area will decrease grazing and space competition on adjacent ranges.

Human Interest Values

SOCIOLOGICAL

Although many of the benefits may be long-term, rapid rehabilitation of any burned forested areas will provide numerous favorable social impacts. Use of scarce petroleum products is an adverse impact.

Rehabilitation following wildfires will help maintain employment, particularly in the timber-producing areas. Demands for all forms of outdoor recreation are growing at an accelerated rate. Improving habitat for game species could improve hunting conditions. Reforestation projects could also provide future opportunities for bird watching, rockhounding, hiking, scenic photography, and other recreation activities. As areas are rehabilitated, uses can usually adjust to new patterns with minor impact.

CULTURAL RESOURCES

A direct positive impact of postsuppression activities can be the identification, evaluation, and protection of key archeological sites found during forest reestablishment and other practices. An estimated 80 percent of the remaining surface archeological sites will be discovered by field surveys in areas where vegetation allows visual examination of the ground.

AESTHETICS

Fire-blackened landscapes are rarely aesthetically pleasing, but they can be managed to minimize adverse impacts. Extensive scorching of tree trunks is another feature that may be asethetically unacceptable to some segments of the public. In the hot desert successful rehabilitation is extremely difficult. Therefore, activities involving surface disturbances can yield impacts of a long-term nature.

The discontinuance of fire operations may also have positive impacts on the visual environment. Rehabilitation of groundcovering vegetation will tend to reduce the impact of the disturbed soil.

IMPACTS FROM PRESCRIBED FIRE PRACTICES

Soil

The effects of fire on soil are largely secondary. They are, to a considerable degree, by-products of the more direct effects that fire has on vegetation and microclimate. It is difficult to distinguish the effects of fire on soil because they are similar to those produced by other influences such as grazing, logging, and any other activity that causes site disturbance. The effects may be good as well as bad.

Fire impacts on soil are controlled by a number of factors (Brown and Davis, 1973). Some major factors are fire frequency, soil heating, ground mantle characteristics, soil characteristics, and release of minerals.

Fire Frequency. The influence of fire may differ widely depending on burn frequency. Some vegetative types are subject to frequent burns, others are not. The organic mantle overlaying the mineral soil often constitutes a significant part of the combustible fuel available and it has a great deal to do with the impacts of fire on soil. Occasionally, a major part of this organic layer may be consumed by fire but, under most conditions, lower layers are moist and an initial fire does not burn the entire mantle. A subsequent fire is usually much more damaging because it burns lower organic layers.

Repreated fires are not necessarily bad, however. Periodic fire to reduce competition from competing vegetation and to expose mineral soil is considered to be necessary for maintenance of the Douglas fir forests west of the Cascade Mountains and the pine forests of the south (U.S. Environmental Protection Agency, 1973). Fire is also needed to remove competition and provide a mineral soil seedbed for the reestablishment of lodgepole pine where it is being replaced by spruce-fir forests, and to reproduce the redwood forests.

Soil Heating. Fires vary from those of low heat intensity and short duration in grass stands to relatively long duration and high heat intensities in forest slash and ground fuels. Low intensity, long duration fires occur in duff and peat.

Heat from burning is transmitted by convection, radiation, and conduction. Of the heat released, 70 to 80 percent is upward through convection. Heat transmitted downward to the soil is, therefore, limited. Temperatures above the soil surface in hot fires may approach 2,000°F. The soil surface may reach 400°F from radiated heat, while temperatures below the surface depend on conducted heat and decrease rapidly with depth.

The direct heating of soil by fire is usually a minor consideration. It becomes important only with fire of considerable intensity and duration. With such burns on heavier soils, colloidal structure may be changed and particles baked into larger aggregates. Frequently soil wettability is reduced under intense burns.

Lethal damage to soil organisms in most forest fire might extend down from 1 inch to as much as 3 inches during prolonged firs in heavy fuels.

Some surface-soil temperature increase is experienced through blackening of the surface and consequent increase in heat absorption. This phenomenon is also aided by the removal of shade from the burned site. Whether these soil temperature increases are desirable or not depends on the net effect on establishment of natural reproduction. Destruction of the living cover is of much greater importance than a blackened surface in raising soil temperatures and dryness.

Warming of the soil after fire as a result of exposed conditions will accelerate decomposition of any remaining organic materials and can result in increases in soil organisms. This oftem permits the establishment of different vegetation cover.

Ground Mantle Characteristics. The layer of unincorporated organic material can vary from a negligible amount of litter in desert types to a foot or more of partially decayed vegetative material in some coniferous forests.

Environmental changes occur due to removal of ground mantle. Exposure of the soil surface may permit severe erosion along with accelerated surface water runoff. This is frequently a most serious and long-lasting result of fire. Surface compaction can occur when mineral soil is exposed, and infiltration capacity is often reduced by sediment-laden runoff.

Exposed soil following fire will usually suffer a reduced moisture content. However, this added evaporational loss might be countered by the removal of vegetative having high transpirational rates. These influences make the effect of fire on soil moisture extremely variable.

Important chemical effects may be brought about by changes induced by fire in the vegetative cover. For instance, increased growth of grass and forbs following burning contributes more organic material and biological activity to the soil than did accumulations of pine needles before the tree cover was burned.

Soil Characteristics. The physical characteristics of the mineral soil itself strongly influence the effects fire may have on the soil. Texture, structure, and moisture content vary widely in different soils, as do such physical and chemical properties as thermal conductivity and colloidal content. Susceptibility of surface soil to changes as a result of heating is rather high due to its content of soil organisms, organic matter, and colloids.

Soil is generally a poor conductor of heat. While soil organisms may be affected, no actual combustion of organic matter below 1 inch could take place from most natural fires. Coarse textured soils heat more readily than the clays and as moisture increases thermal conductivity, moist soils are generally cooler soils.

Soil temperatures developed at different depths are illustrated by thermocouple measurements made during fires in California chaparral (Sampson, 1944). Table III-1 gives such depth and duration data for different kinds of chaparral stands.

Release of Minerals. The release of minerals in the ash generally results in a reduction in soil acidity and an increase in available plant nutrients. The released mineral elements are leached down into the soil. If they are not lost through the leaching and eroding process, replaceable calcium, potash, phosphoric acid, and other substances are temporarily more abundant for plant use. On heavier soils, they may persist for extenced periods.

Although mitrogen is lost into the air from combustion of organic material, the amount of available nitrogen in the soil is usually increased following a burn. More favorable soil and vegetative conditions for nitrification appear to be the main reason. Reduced soil acidity may stimulate nitrification.

Mineral nutrients tend to cycle within an ecosystem rather than flow through it. They are taken up from the soil by plants, become a component of litter, and ultimely return to the soil. Rainwater and weathering processes provide materials, while water and animals remove them. Minerals in letter and wood may be released slowly by microorganisms or rapidly by fire. Heat from fire may also hasten the weathering of soil minerals. After a fire, there is usually an abundance of soluble minerals available for increased plant growth. A large part of these may also be removed by runoff and leaching. (Despain, 1972).

The time of burning affects fire's influence on soil chemical properties. On tall grass range, winter burning caused greater changes, with higher soil pH, organic matter, calcium, magnesium, potassium, and lower soil nitrogen than did burns at other seasons (Ownesby and Wyrill, 1973).

Water

Impacts of prescribed fire on water, like those on soil, are largely secondary resulting from fire's primary influence on vegetation and the microclimate. Fire may affect the quantity and quality of water both on watershed and far downstream.

The use of fire in resource management can have great significance with respect to water resources. Water yields can often be increased by removing stands of heavy water-using plants and allowing replacement by those with lower water requirements. Currently prominent in such conversion efforts are chaparral and woodland types. These deep-rooted, woody species after burning may be largely replaced by herbaceous cover. Results generally involve a lowering of peak flows, greater and longer flow springs, and improved moisture relations through better infiltration and percolation into the soil. Some other tree and shrub stands can also be beneficially treated for conversion to a more water-conserving condition.

Table III-1. Litter and Soil Temperatures in California Chaparral Types During Burning*

Vegetation	Depth of thermocouples, in.	Maximum temperatures F	Minutes to reach maximum temperature	Minutes temperature remained over 150 F
Chamise, fairly dense	On soil surface	635	9	3
grasses and weeds	3/4 in. in soil	320	9	12
	1-1/2 in. in soil	230	16	17
Mixed chaparral of	1/2 in. in duff	840	4	40
blue oak, dwarf	1/2 in. in soil	410	7	61
interior live oak,	1-1/2 in. in soil	235	14	74
wedgeleaf ceanothus				
with scattered herbs				
Wedgeleaf ceanothus	1/2 in. in litter	300	5	11
with scattered	1/2 in. in soil	200	1	5
grasses	1-1/2 in. in soil	+		
Common manzanita,	1/2 in. in litter	960	8	34
scattered grasses	1-1/2 in. in soil	215	16	17
and weeds				

* After Sampson (1944).

\+ Below 150 F. Instrument does not record below this temperature, and hence, no reading.

Planned burning to remove underbrush from tree stands can alter the quality and yield of water by adding available nutrients, exposing soil to more direct raindrop action and increasing runoff and sediment loads. These impacts can be of short duration and eventually return to prefire conditions.

The total volume of water received on an area as precipitation will be redistributed within the ecosystem if vegetative cover is removed by burning. Although there have been few direct studies made of fire effects on water storage and yield of watersheds, observations during related studies and after fires have provided some general information. The most apparent changes have been in two factors, surface runoff and soil moisture.

Increased surface runoff can be expected from most fires. Not only is the obstructing vegetation removed, but a hot burn can make soils water repellant for a time.

Many areas dominated by herbaceous cover have been invaded by woody, deep-rooted brush and trees with a consequent drying up of springs and seeps. Fire often had held back invading trees and shrubs. Fire prevention and control, along with overgrazing by livestock, tipped the ecological balance in favor of woody plants. Frequently, this invasion was accompanied by large, oversurface flows of water. Springs often started flowing again in greater amounts and over longer periods of the year with the reestablishment of shallow-rooted vegetation.

Openings in the vegetation canopy influence moisture relationships of a burned area. The size, distribution, and orientation of such openings determine evapotranspiration rates and influence water yield of streams. Snow accumulation is modified along with time of snowmelt and amount of runoff. Most studies indicate that large openings in tree stands will advance the time of snowmelt, thus increasing peak flows and amount of early stream runoff. Some evidence shows that snowmelt is delayed a few days in small openings on leeward, north slopes in some intermountain areas.

Stream discharge fluctuations due to fire are often difficult to distinguish from normal annual fluctuations. However, when significant portions of a watershed are burned, changes in total discharge volume are often experienced.

The burning of plant cover may increase groundwater temporarily by removing plants that transpire heavily. However, this may be offset if evaporational losses are increased because the burn removed shading vegetation.

Time of burning can have a significant influence on soil moisture. Winter burning of prairie grassland, leaving the soil surface unprotected from losses by runoff, evaporation, and surface erosion for a long period

before new growth begins, will lower average annual soil moisture more than burns later in the season (Anderson, 1965; Anderson, et al., 1970).

Prescribed burning will either directly or indirectly have some effect on physical and chemical nature of water from a watershed. The extent of water modification is dependent on a number of factors including:

- Extent and intensity of the burn,
- Amount of resultant runoff,
- Erosion susceptibility of soil,
- Soil constituents,
- Amount and kind of vegetal cover.

Each of these has a definite bearing on the change a fire may make in the usefulness of water from a given area. Most of the immediate, short-term changes induced by fire are undesirable. The long-range influence often enhances water quality over the condition existing before a burn. A change from woody to herbaceous cover will sometimes provide this. In any event, the ultimate result of fire appears to be more often desirable than detrimental with respect to water quality and other site factors.

Water quality is altered by fire through its influence on plant nutrients, salinity, sediment load, turbidity temperature, and oxygen content.

Fire is likely to release large quantities of chemical ions that may be lost from the soil surface and reach streams through leaching and soil movement in runoff. This introduction of nutrients into aquatic ecosystems may be excessive. The extent of leaching and soil erosion, and any consequent eutrophication of streams and lakes, will vary with a number of factors some of which are:

- Cation exchange capacity of soil,
- Intensity of fire,
- Proximity of fire to stream channels,
- Period between fire and precipitation,
- Intensity and duration of precipitation,
- Period between burn and revegetation,
- Nature of revegetation.

When affected by microorganisms, the recycling of mineral residue from vegetation is slow, but burning greatly accelerates the process. Organic materials, both living and dead, are rapidly oxidized by fire into ash. From this residue, subsequent precipitation dissolves some of the chemicals and carries it either into the soil or into streams. Concentrations of cations (calcium, magnesium, potassium, sodium) may be greatly increased after fire for a few years with gradual diminishment to preburn levels (Rothacher and Lopinshinsky, 1974). These minerals can be in solution in streams or absorbed by sediment particles. Nitrate nitrogen concentrations also show increases for varying periods after many fires.

Currently, the most effective and widely used chemicals to control forest fires are made in formulations of ammonium sulfate and diammonium phosphate. These compounds are actually plant fertilizers and enhance the growth of trees and other plants, but their release into surface waters can yield toxic concentrations of ammonia and promote eutrophication (Blahm et al., 1972).

Occasionally a situation may be encountered where the water of a stream is so pure as to be quite sterile for the production of aquatic organisms. Nutrient enrichment from burning adjacent plant cover could be a very favorable change. Such enrichment within appropriate limts might benefit many streams and lakes, depending upon the kinds of organisms stimulated and populations reached.

Changes in water salinity in streams and lakes due to the effects of fire could produce a minor adverse impact. The accompanying increased runoff would tend to counteract the effect.

The ability of a soil surface to resist erosion depends on its textural structural characteristics and slope gradient. These determine infiltration and percolation rates, along with water-holding capacity. The differentials in erosion resistance between soils create productivity mosaics within systems. These appear as areas that are biological sterile or in various stages of plant succession.

When water yields are increased, stream channel morphology may be changed by the erosive forces produced. This adds to the sediment load which may already have been augmented through surface erosion on the watershed. The movement of sediments usually aggravates the runoff problem by reducing soil porosity and clogging stream channels and lakebeds.

The enrichment of streams and lakes from soil erosion is usually accompanied by increased water turbidity. Such reduced light intensity places a proportionate limitation on productivity of the aquatic habitat. It has been postulated that this modification of a production factor would tend to offset the growth stimulus provided by eutrophication.

Fires temporarily influence energy flow in an ecosystem by direct release of heat at the time of the burn; but also, more importantly, by reduction of shading from the vegetation cover. This results in higher temperature of surface water and soil, thereby influencing soil moisture relations and microclimate. The total effect on the system varies with the type and intensity of burn, slope, exposure, elevation, and soil properties.

If fine organic residues get into streams, biochemical oxygen will increase and influence stream biology. This added demand aggravates any overproduction situation engendered by stream enrichment as a result of fire. The aquatic ecosystem may become incapable of supporting a desirable array of organisms.

Several factors affect the quality of a stream as a fishery. Some of the more important are water temperature (both directly and indirectly as it influences oxygen availability), rate of flow, fluctuation of discharge, availability of shelter, and any sediment load. Fish distribution is controlled by channel morphology, deviation of flow, and presence of suitable food organisms. Of these various factors, fire can most directly change shelter through removal of vegetation adjacent to the stream. This could reduce local fish populations for short periods until resprouting of streamside shrubs has occurred.

Sediment load resulting from fire will or will not be detrimental to a fishery depending upon the amount and size of particles. Sand grains settle out quickly and usually do little damage. Silt-sized and smaller particles are suspended a longer time and may be carried to spawning gravels. Here it may seal the gravel beds and prevent oxygenated water from reaching the eggs.

Air

The effects of air quality of fire prescribed to accomplish resource management objectives are identical to the effects of fire used for hazard reduction. Though there may be a greater diversity in the kinds of burning operations, possibly more combinations of natural fuels and a greater frequency of low intensity area burning, no new air quality considerations are introduced.

If an ignition occurs in a predesignated prescribed fire area and meets the specification of the prescription in terms of fuel conditions, weather, and fire intensity, it may be considered a prescribed fire. One of the requirements for being considered a prescribed fire is that it conform to the limitations on smoke emissions imposed by a smoke management plan, if applicable. The smoke management plan, which must be prepared locally and approved by local air quality regulatory agencies, constitutes local emission standards to assure compliance with State and national ambient air quality standards.

In remote areas, particularly at high elevations, no smoke limitations would normally apply. However, if the combination of existing and expected stability and winds is such that the smoke plume would extend into a smoke-sensitive area, then the provisions of a smoke management plan apply.

Under the plan, the total amount of particulate that the atmosphere can accomodate in a single day is specified for the given conditions, for the individual administrative area. This means that the total particulate emitted from all prescribed fires plus all wildfires in that area may not exceed this total.

Prescribed fires lasting more than a single day must be reevaluated for compliance with air quality requirements each day. Suppression actions may be necessary to assure these limits are met.

Vegetation

Prescribed burning, or the intentional ignition of grass, shrub, and forest fuels for specific purposes, has long been a recognized land management practice. The objectives of such burning are varied: reducing the fire hazard after logging, exposing mineral soil for seedbeds, controlling insects and diseases, improving yields and quality of forage, improving wildlife habitat, and modifying the composition of species in different plant communities.

Today there is a new, additional role for fire on some wildlands. Some areas of national parks and wildernesses are being managed so that wildland fires may play a more nearly natural role. In these areas fires are allowed to burn under observation in accordance with approved plans. Prescribed burns started by man also can restore fires to areas where fuel accumulations hold the potential for fires of unnaturally high intensities. Fire can also be restored by allowing lightning fires to burn within predetermined zones.

Beneficial impacts of prescribed fire on vegetation are:

- Reduced fuel accumulations;
- Control of species composition;
    - o reduction of fire-sensitive species;
    - o improved seed germination of some species; e.g., ceanothus;
    - o open serotinous cones;
    - o increased growth of shrubs and herbaceous plants because more light reaches the ground;
    - o increased sprouting of many shrubs.
- Offset or minimize adverse impacts of fire exclusion from suppression activities;
- Perpetuation of vegetation mosaics in wilderness;
- Accelerated nutrient cycling;
- Stimulated net primary production;
- Enhanced wildlife habitat patterns;
- Control of insects and disease;
- Regulated plant succession.

Adverse impacts of prescribed fire on vegetation are:

- Removal of desired species, especially if fire sensitive (e.g., some bunch grasses are damaged by hot burns in summer or fall);
- Reduced site productivity where distributed by mechnical equipment;
- Temporary removal of soil-protecting vegetation and litter;
- Loss of some nutrients;
- Increased sprouting of undesirable shrubs.

GRASSLANDS

Studies on the southern temperate grasslands by Wright (1972a) and others have shown the impact of prescribed burning, if properly conducted, at the right time, and under the right conditions, is most beneficial to the grassland by increasing productivity and inhibiting such woody growths the grasses are stimulated by the prescribed burning. The grasses are then more palatable, higher in protein and necessary mineral elements. Studies by Gartner and Thompson (1972) in South Dakota on northern remperate grasslands have shown similar results.

DESERTS

The beneficial aspects of prescribed burning in the desert biome grasslands are as follows:

- Reduction of fire hazards,
- Removal of excessive organic matter where proper grazing management is practiced,
- Rejuvenation of grass successional cycle,
- Slowed-down invasion of undesirable brush or woody species or cacti,
- Favoring of desirable species of plants,
- Increased palatability of many species of grasses as well as an increase of protein and mineral content.

Impacts of prescribed burning on grassland vegetation may be either beneficial or detrimental depending upon the kind and condition of grassland, season of burning, intensity of fire, and specific site factors that influence prompt recovery of vegetation. Adverse impacts are primarily the fault of the prescription or of the implementation of the prescription. Proper burning practices can be easily defeated with possible serious consequences by allowing livestock access onto the burned area too soon after the burn. Much degradation of western ranges has occurred because of heavy grazing on the tender grass shoots on burns before the plants are able to withstand such grazing. Under such conditions it is not the fault of the burning but of the livestock management. Not only can the desert grasslands be injured but more erosion and compaction can occur. Where woody species or cacti are invading the range, a prescribed burn of too low an intensity can defeat the control of such vegetation, and in fact enhance that invasion.

WOODLAND-BUSHLAND

Chaparral. Perhaps the most striking impact from prescribed burning in chaparral is the resulting hydrologic conditions where repeated studies have shown highly increased water yields in the younger and grass stages of succession in these vegetations. Increased water yields in the Salt River Watershed are the objectives of large-scale programs of prescribed burning there.

The lessening of severe erosion, enhancement of wildlife habitat, and increased range capabilities have also resulted from such prescribed burning. Philpot (1974) has pointed out that the use of fuel management and prescribed burning in chaparral in the younger age classes of succession would lessen the danger and damages apparently inherent in wildfires occurring in older age classes.

Oak-Woodland. The impacts from prescribed burning in oak-woodland are somewhat the same as in the chaparral. In large sections of California the ranchers burn such areas under the direction of the State Extension Service and the State Division of Forestry as well with the cooperation of the State Environmental Protection Agency. Under this cooperative effort many thousands of acres burned annually for the regeneration of the open grass parkland and the control in invading brush. The water yield is also increased.

The good effects of prescribed burning can be negated by poor prescriptions and poor livestock management. Stocking too early on the burn will harm the grass components; and shrubs will increase in the absence of grass competition. Many of these oak-parklands have so reverted to the brush stage, they are termed "oak-woodland brush lands." Wherever the brush is controlled and an oak-parkland is maintained, they are considered some of the finest of livestock rangelands. The control of the brush, if not overdone, also enhances this habitat for many forms of wildlife.

Pinon-Juniper. Pinon-Juniper invasion into grasslands has been attributed to overgrazing and fire exclusion. In many areas overgrazing has been the primary cause of pinon-juniper invasion. Once the grassland is under good management then prescribed burning becomes an excellent management tool.

The impacts from prescribed burning in pinon-juniper can vary from adverse to very beneficial depending upon methods used to regenerate the rangeland. The use of such methods as bulldozers and chaining, creating considerable soil disturbance, are not always beneficial. The usual practice in such areas is to pile the pinon-juniper, burn the piles, and then reseed the range with both exotic and native range grasses. There does seem to be a trend toward using more and more native grasses.

Another method of reclaiming pinon-juniper land is to remove livestock and allow continuous ground fuel to develop for a broadcast burn. However, competition from old stands of pinon and juniper often will preclude the development of enough grass for a good fire. The good effects of burning, such as better and more palatable grasses, better water yield, less brush invasion, and improved range productivity can all be negated by a poor prescription and poor livestock management after the burn. Also, prescribed burning is no miraculous tool and it cannot always remove the effects of many years of poor land management. The problems that have developed in all three of the divisions in this oak woodland-bushland biome have been caused by many years of poor land management.

CONIFER FORESTS

In coniferous forests characterized by dry, cool growing seasons, the process of decomposition barely functions and fuels accumulate. Fire suppression actions have often led to excessive fuel accumulations in many environments (Dodge, 1972). Prescribed burning can be used to reduce the accumulating fuels under controlled conditions. Understory burning has been successfully demonstrated to reduce fuel accumulations in the larch/Douglas-fir type (Norum et al., 1974). Duff removal has been successfully accomplished by prescribed burning in ponderosa pine (Davis et al., 1968). Prescribed burning has reduced fuel loads by 50 to 85 percent in forests protected from fire for many years (Weaver, 1957; Biswell, 1963). Fall burns often consume more fuel than spring burns, because the fuels are drier. Up to 85 percent of the duff and 45-95 percent of the larger fuels were consumed by a fall prescribed burn (Kilgore, 1972).

Species composition can be materially affected by prescribed burning. Herbaceous vegetation almost always increases. Though some species decrease or remain stable, many increase after burning in a mixed conifer forest (Hartesveldt and Harvey, 1967). The release of nutrients, better carbon-nitrogen ratio, less litter, and more light resulted in the increase of herbaceous vegetation under ponderosa pine (Moir, 1966; Davis et al., 1968) and in mixed conifer forest (Kilgore, 1971; Rundel, 1971).

Prescribed burning often favors shrubs in most coniferous forests. Shrubs require adequate light to become established under a mature forest (Kilgore, 1972). Many shrubs have fire-resistant seeds or they have the ability to sprout and can increase after a fire (Sweeney, 1967; Buchanan et al., 1966). Nonsprouting shrubs with seeds stimulated by fire, such as little leaf ceanothus, and deerbrush, often increase after fire (Hartesveldt and Harvey, 1967).

The numbers and species composition of trees can be markedly altered by prescribed fires (van Wagtendonk, 1972; Kilgore, 1972). Generally, fire-resistant trees are favored by prescribed fire and fire-sensitive trees are reduced. Prescribed fire helps prepare a seedbed for regeneration of future crops of trees. Burning reduced duff and litter accumulations and exposes mineral soil necessary for seed germination and survival.

Zivnuska (1972) described a series of costs associated with undesired consequences of the prescribed use of fire:

> "Examples of such undesired consequences include the killing of regeneration which is desired, the loss of nutrients either directly in the combustion process or indirectly through accelerated runoff, the development of fire scars on crop trees, and loss of aesthetic quality during the period in which evidence of the fire is readily visible. Obviously, the magnitude of such costs will vary tremendously both with the success of the presribed burning and from property to property."

TUNDRA

Although fire is natural in true tundra communities, it occurs infrequently. Certain lichen components are fire sensitive and take from 40 to 100 or more years to recover (Scotter, 1971). The "fire mosaic" of the true tundra was probably made up of many small burns over long periods of time. Cochrane and Rowe (1969), Scotter (1971), and Kruichkov (1968) all discuss fire as a natural factor but point out that much of the tundra is very sensitive to regular overburning by man. In fact Kruichokov (1968) points out that adjacent to the taiga or other tree zones repeated, unnatural fires can develop what he calls a "pyrogenic" tundra. In Russia he states:

> "At the treeline in burned areas tundra appears which we suggest calling pyrogenic ....
>
> "After several tens of years pyrogenic tundra can no longer be differentiated from primary tundras in aerial photographs. In trips on pyrogenic tundras one usually finds burned stumps either at the soil surface or under a thin layer of moss."

However, pyrogenic tundra could well be a natural phenomena as well as man-developed around settlements. The region between the taiga, conifer forest, muskeg, and the tundra proper is a fragile and greatly fluctuating zone depending on weather variations or cycles and lightning fluctuations. The interior of Alaska, with a mixture of plant communities, is a predominant lightning fire zone. In addition, there are certain areas where man-caused fires are also abundant.

Wildlife

TERRESTRIAL

Prescribed fires commonly consist of broadcast (or area slash) buring, piling and burniing of debris, and light underburning, as forestry practices. Control fires may also be set in non-forest biomes for other resource benefits, including wildlife habitat improvement. Secondary benefits to wildlife may accrue from control of disease hosts.

Favorable impacts of prescribed burning (and sometimes accidentally achieved by wildfires) include the control of recycling of plant succession, as discussed in Part III, this volume, under "Impacts From Suppression Practices." Most, but not all, wildlife species prosper when fire breaks up extensive, homogeneous stands into a pattern of different vegetation types of various ages. High quality food is produced abundantly for many wildlife species. Adverse impacts on wildlife can result from controlled burning if adequate care is not given. For example, the direct loss of nests or young animals if spring fires are ill-timed (Stoddard, 1931; Leopold, 1933). Most animals easily escape fire by avoidance; some are attracted to smoke and to fresh black burns (Komarek, E., 1969).

Grange (1949) said the role of controlled fire as a method of increasing game is always that of partial denudation to induce an earlier succession or to expose the soil to sunlight and air. Fire is a natural method of initiating succession. Fire on game ranges is best applied on a rotation system. The role of fire in deciduous vegetation is one of pruning to produce vigorour new growth; usually, fruit production also increases. Fire may reduce populations of various insect pests and parasites. It reduces cover utilized by rodents. Burning produces some immediate fertilizer effect. It stimulates some hard shrub seeds to germinate. Controlled burning reduces danger of large wildfires. Prescribed burning, preferably after crushing, is done to open up stands of chaparral in California to provide access for deer and improve forage quality. Deer use may ten times (Dasmann et al., 1967). Available forage may increase from about 50 pounds per acre to 1 ton, and protein content from 1 percent to 6 percent (Hendricks, 1968). No wildlife species is totally eliminated following a chaparral fire, nor is there any reduction in total life on a burn after plant growth resumes. One immediate effect of fire was a large increase in predatory mammals and birds, including coyotes and badgers, and especially hawks and owls. Populations of most small mammals and some birds decreased rapidly. Birds and mammals typically preferring brush habitat were substantially reduced in numbers in the years following the burn. Conversely, some birds preferring open grassland or oak-woodland increased in number. Fire resulted in an overall increase in densities of nesting birds.

None of the small mammals increased in numbers (Lawrence, 1966).

Heady (1972) reported that in the California annual grasslands, there was an immediate reduction in rodent numbers following fire, but a few of all species survived. Populations recovered within a few years.

A prescribed burn in the red fir type King's Canyon, California, resulted in no noticeable change in deer or bird numbers (Kilgore, 1971). Redfield, et al., (1970) found blue grouse density was as high on logged and slash-burned areas as on burns.

Prescribed burning trials in the mixed-conifer forest of northern Idaho were made to rejuventate shrub species used by deer and elk. Animals preferred the new growth on burns regardless of species. Normally unpalatable shrubs were much better used after burning. Effects lasted at least through two winter seasons (Leege, 1969). In the same area, Lyon (1966) found that prescribed fires increased browse availability and at least doubled its quantity within two years. Peak effects should last about 15 years.

In large homogeneous expanses of dense sagebrush, small controlled burns could improve habitat for sage grouse. Fire can control sagebrush invading meadows which are primary summer habitat. Production of forbs, utilized as food, increased on burned sites. Sage grouse wintering habitat should not be burned. Burned areas in sagebrush are also attractive to sharp-tailed grouse and chukars will return to a burn almost immediately following a fire (Klebenow, 1972).

Handley (1969) observed that mammals living where fire is a frequent and regular occurrence, as in grasslands, are adapted to survive fire. But fire often is a disaster for mammals dwelling where fires are infrequent.

In general, the beneficial effects of burning far outweigh and offset any direct wildlife losses (Vogl, 1967). For further references to fire impacts on wildlife and habitat see Stanton (1975).

AQUATIC

The immediate effect of fire on streams could be an increase in stream temperature. The size of the stream and intensity of the fire would determine the amount of water temperature increase. Any significant increase could stimulate insect emergence (Waters, 1972). Adult aquatic insects and terrestrial insects could be destroyed when streamside vegetation burns, but these areas are quickly recolonized.

Addition of organic matter to the stream from needle drop, forest litter and ash associated with fire could have a profound effect on the stream environment by altering water chemistry (Bergersen and Galat, 1974). In a study of the effects of yellow pine litter on small lakes, Seawell (1967) found that leachates from tree litter reduced alkalinity, added

color, and increased oxygen demand and biogenic salt concentrations (phosphate and nitrate) as well as the organic load on the lake waters. Similar changes are likely to occur in a stream system in the event of an extensive needle drop in or even near a stream in a burn.

Effects of fire on aquatic habitat are the temporary loss of streamside vegetation and the cover it provides for fish and a possible significant increase in solar radiation. Sedimentation resulting from fire can clog the gills of invertebrates and young fish, increase suspended materials, inhibit primary production, fill bottom substrate interstices with fine sediments and reduce invertebrate and fish spawning habitat (Bergersen and Galat, 1974).

Domestic Animals

As with wildfires, it is necessary to protect prescribed burns from grazing until native vegetation and/or seeded species become established. Harniss and Murray (1973) stated that improper grazing practices after burning result in serious deterioration of vegetation and soil.

However, protection programs such as fencing or removal of livestock from the area can be planned well in advance thus greatly reducing the detrimental effects to livestock, the livestock owners, and other resources as discussed in the postsuppression program.

The beneficial effects of prescribed burning on the production, quality, and nutritional value of livestock forage are widely recognized. Prescription burns that take advantage of environmental conditions such as soil moisture, relative humidity, and wind to achieve desired burn intensities and which have a minimum adverse impact on desirable vegetation greatly increase grazing capacities for livestock.

The conversion of types, such as pinon-juniper, to grass types through prescribed burning will greatly benefit livestock. The removal of pinon-juniper, either by fire or mechnical means, is the primary way that forage production for livestock and wildlife can be increased.

Prescribed burns in forest types also increase forage. Agee (1974) indicated prescribed burning in forest types generally favors shrubs, herbaceous plants, and grasses because light penetration is increased and the forest floor is reduced.

There have been many studies showing that prescribed burning increases the nutritional value of vegetation. Prescribed burning of pine bluestem ranges during proper time of the year will increase protein content of the forage. High intensity prescribed burning in east coast browse types

significantly increased the protein content of the new plants.

Increased grazing capacity resulting from prescribed burning will also provide the opportunity for shifting livestock use from overgrazed areas. This will benefit livestock production and other resource values.

Wild Horses and Burros

Prescribed burning would remove some vegetation preferred by wild horses and burros for at least one growing season or until the area could be grazed. The adverse impacts of precluding use of the area by the animals would be the same as in postsuppression rehabilitation. However, the magnitude or seriousness of the impacts would not be as great.

The beneficial impacts of prescribed burning involves changing species composition and vegetal conversion most beneficial to wild horses and burros.

Human Interest Values

SOCIOLOGICAL

Although the risk of wildfire is reduced by the release of energy in a prescribed burn, there is always a risk of the fire escaping its planned limits (Zivnuska, 1972). From an economic standpoint, prescribed burning is becoming relatively less expensive than a policy of suppressing all fires. Where wildfire threats exist, prescribed fires can reduce fuel loads and reduce the danger of destroying human resources. In high value ares, prescribed fires could be used to protect areas such as campgrounds and other important visitor use areas from wildfires.

Fire by prescription would have a lesser impact on wilderness values than fire suppression where fire has been identified as a natural component of the wilderness ecosystem.

CULTURAL RESOURCES

Natural and Indian fires burned for many centuries at various intervals. Thus, most sites that would be prescribed burned today were burned over countless times up to 60-80 years ago. The impact of prescribed fires on sites and objects may be limited to undiscovered artifacts of the last years of Indian occupation. Sites, such as wooden structures and artifacts in dry caves may be directly lost by burning in fires. Prescribed fires may be benefically used to recreate prehistoric and historic scenes for interpretaive purposes, as most of the Indians

as well as the early settlers used fire to manipulate their environments (Lewis, 1973).

AESTHETICS

Many visitors experience much of the landscape by means of the automobile. Travel time is often a period of great value as a scenic experience. Scenic and landscape factors must be evaluated when prescribed fires are applied to any area. Prescribed fires may create a non-natural landscape if the fire is not applied with landscape maintenance or restoration as an objective. Distance vistas may be temporarily blocked if visibility is reduced by smoke from prescribed fires.

Prescribed fires can also enhance the landscape, as maintaining fire-dependent plant communities. But fire-deadened understory trees may remain upright for several years and lend a temporary ugly appearance to the understory. A second fire in several years can remove these trees, by transforming the landscape from a dense understory to an open park-like condition (Agee, 1974).

Prescribed fires can rarely be uniformly applied to an area, and the resultant variety can add to the sequence of landscapes (Meskimen, 1971). Care must be exercised to prevent large-scale uniformity unless this is a natural landscape feature.

SUMMARY OF MAJOR ENVIRONMENTAL IMPACTS
OF THE FIRE MANAGEMENT PROGRAM

Beneficial and adverse impacts can occur in varying degrees due to the proposed fire management program. These impacts may occur off-site as well as onsite. The major impacts are outlined as follows:

1. <u>Beneficial</u>

a. <u>Presuppression-Prevention Practices</u>

(1) Soil and Water
- Reduce the number and size of wildfires

(2) Air
- Reduce smoke production caused by wildfires

(3) Vegetation
- Inhibit damaging insect and fungi outbreaks
- Increase availability of nutrients
- Improve seedbed conditions

(4) Human Interest Values
- Facilitate human access
- Create aesthetically pleasing variety on the landscape
- Discover archeological and historical features

b. <u>Suppression Practices</u>

(1) Soil and Water
- Limit loss of vegetation cover on watersheds

(2) Air
- Reduce smoke emissions

(3) Vegetation
- Maintain conditions favorable to plant succession
- Protect endangered species of fire-sensitive plants

(4) Wildlife
- Limit loss of habitat for some animals
- Protect some endangered species of animals

(5) Domistic Animals
- Limit loss of forage

(6) Wild Horses and Burros
- Limit loss of forage

(7) Human Interest Values
- Protect human life and man-made structures
- Protect archeological, historical and other unique sites, and resource investments
- Provide temporary stimulus to local economy

c. <u>Postsuppression Practices</u>

(1) Soil and Water
- Reduce wind and water erosion of soil
- Reduce stream pollution
- Restore desired plant species for watershed protection

(2) Vegetation
- Reduce fire hazards
- Inhibit damaging insect outbreaks

(3) Wildlife, Domestic Animals, Wild Horses and Burros
- Restore habitat and forage

(4) Human Interest Values
- Improve recreational opportunities
- Identify and protect archeological sites
- Improve visual aspect of the landscape

d. <u>Prescribed Fire Practices</u>

(1) Soil and Water
- Reduce number and size of wildfires
- Long-term increase in water quality and/or yield

(2) Vegetation
- Restore and/or maintain plant succession of desired stages
- Increase availability of nutrients
- Improve seedbed conditions

(3) Wildlife
- Improve habitat conditions

(4) Domestic Animals, Wild Horses and Burros
- Improve forage conditions

(5) Human Interest Values
- Perpetuate fire-dependent ecosystems in wilderness
- Maintain a pleasing diversity of life forms on landscape

2. Adverse

a. Presuppression-Prevention Practices

(1) Soil and Water
- Onsite loss of some nutrients due to hazard-reduction burning
- Temporary decrease in wettability of soils due to burning
- Reduced productivity of soil from intense heat generated under heavy concentrations of fuels; a localized effect
- Accelerated soil erosion from roads, trails, friebreaks; possible increase in sediment loads in streams
- Complete removal of forest residues (clean logging) (may deplete storehouse of abailable nutrients)

(2) Air
- Smoke from burns prescribed to reduce fuel hazards can lower visibility and adversely affect people with respiratory ailments

(3) Vegetation
- Loss of vegetation during construction of detection facilities, access roads, guard stations, firebreaks, helispots
- Logging slash treatments consisting of chipping, chopping, chaining, compacting, or rolling may reduce fire hazard, but adversely affect tree regeneration and site productivity

(4) Wildlife
- Temporary disturbances to wildlife
- Removal of snags and vegetation can lead to loss of wildlife habitat

(5) Human
- Disturb aesthetic values
- Loss or damage to natural areas and geological, archeological, or historical features

b. Suppression Practices

(1) Direct Effects

(a) Soil and Water
- Fireline construction by bulldozers can cause more erosion damage than the fire; especially true in tundra, taiga, and desert ecosystems; contributes to decline in site productivity

- Fire retardants may produce unacceptably high levels of nitrogen and phosphorous in streams and lakes
- Soil compaction on roads, firelines, and fire campsites contributes to greater runoff and soil movement

(b) Vegetation
- Localized destruction of vegetation at helispots, fire camps, fire lines

(c) Wildlife, Domestic Animals, Wild Horses and Burros
- Temporary disturbance due to human presence

(d) Human INterest Values
- Access roads, firelines, and helispots may degrade the aesthetic appeal of an area

(2) Indirect Effects

(a) Soil and Water
- Fire exclusion over time eventually may result in more severe fires, larger fires, and extensive watershed damage on some sites (due to fuel accumulations)
- Fire exclusion over time can tie up nutrients in litter and duff layers

(b) Vegetation
- Loss of life form, species, and age class diversity of vegetation as fire suppression reduces acreage burned (shrubs and trees invade grassland, shrubs decline in forests, herbaceous vegetation declines in woodlinds and forests)
- Fire-dependent vegetation not as abundant on landscape (some of the more commercially important species are post-fire species). Some plant communities are maintained by a certain periodicity of fires

(c) Wildlife
- Major impact on wildlife occurs when vegetation succession progresses toward large expanses of mature homogeneous types in absence of periodic fires. Food and cover requirements often are fulfilled by a mosaic of different successional stages

(d) Domestic Animals, Wild Horses and Burros
- Long-term loss of forage occurs as shrubs and conifer encroach into grasslands in the absence of periodic fires

(e) Human Interest Values
- Loss of parks, meadows, openings, and the vegetative mosaic degrades the aethetic appeal of areas.

c. Postsuppression Practices

(1) Soil and Water
- Salvage logging could impact streams by disturbing streambanks and increasing water temperature and silt load

(2) Wildlife
- Construction of roads and landings, equipment operation, vehicle access, tree cutting, and snag removal may disturb wildlife and reduce habitat

(3) Domestic Animals
- Short-term reduction in forage areas during rehabilitation (numbers of animals reduced or animals removed)

d. Prescribed Fire Practices

(1) Soil and Water
- Soil wettability temporarily reduced by intense burns
- Removal of ground vegetation, litter, and duff may lead to increase runoff and accelerated erosion
- Some short-term loss of nutrients may occur

(2) Air
- Smoke may obscure visibility; smoke could be determental to people with respiratory problems

(3) Vegetation
- Temporary loss of streamside vegetation could occur
- Removal of some desired species if fire sensitive
- Promote sprouting of undesirable shrubs
- Burning may set lechen communities back many years on some sites

(4) Wildlife
- Fires may cause death of animals if ill timed
- Burning toosmall an acreage may concentrate animals on preferred postfire vegetation and such overuse will degrade the site
- Direct loss of some habitat (rotten logs, snags, cover, drumming logs for grouse, etc.)
- Temporary loss of aquatic and terrestrial insects when streamside vegetation burns

(5) Human Interest Values
- Postfire blackness objectionable to many; however, this is generally a short-term effect (often only a matter of days or weeks on range lands)

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PART IV

MITIGATING MEASURES INCLUDED IN THE PROPOSED PROGRAM

The measures individually described for each component of the environment in this section represent, collectively, the actions to be taken in mitigating the impact of the fire management program on the environment. Many practices identified as part of the proposed fire management program are in themselves mitigative in preventing or restoring any ecological imbalances or damage incurred in the course of carrying out practices that may disrupt the ecosystem. For example, the postsuppression rehabilitation projects are all designed to correct damage to the environment caused by fire and its suppression.

The effectiveness of all measures described in this section depends upon sound planning, coordination with other resource activities, professional expertise, careful on-the-ground administration and cooperation from the contractor or user.

The proposal recognizes that certain adverse impacts occur, as discussed in part III and summarized at the end of that section.

Impacts that can be mitigated, at least in part or under certain conditions, or at certain times, are discussed in this part.

Accidental impacts caused when personnel fail to carry out a job or project according to plan are generally not considered impacts as discussed in this part.

This presentation is organized to show impacts on the various resources but without reference to the fire management activity or practice. An impact may be common to several activities. This format minimizes duplication without loss of identity of the adverse impact or effect. Reference to part III will readily reveal the management practice causing the impact.

SOIL

LETHAL HEATING OF ORGANISMS

Since the nature of soil and soil organisms are so closely correlated, the mitigative measures for minimizing or eliminating the adverse impacts of fire management practices on soil apply also to organisms. These measures primarily shorten the already relatively short-term impacts that most practices have on the population and equilibrium of soil organisms. Reduction in the fire intensity and duration at a given spot lessens the impact. Prescribed burning, is in itself, a mitigating measure, for such fires are conducted when soil moisture and other factors prevent undue heating of the soil and the soil organisms. Except under intense burning, as in the case of slash piles, there is little heat penetration into mineral soil.

ACCELERATED EROSION

Practices under presuppression-prevention activity are directed toward the mitigation of adverse fire effects expected if no ameliorative conditions are provided in advance. Of greatest importance is hazard reduction through slash or natural undercover removal and the construction of firebreaks. These preventive practices modify impacts on soils primarily by reducing fire intensity.

Size of fires is kept within smaller limits. This tends to minimize surface and channel erosion per unit of area burned.

Firelines constructed in a manner to cause the least disturbance, and subsequently water barred and revegetated where critical conditions exist, are mitigative measures. Hydromulch (wood cellulose fiber pulp) can be applied to provide immediate protection.

Use of equipment in constructing firebreaks, access roads, and detection sites should be so limited that minimum damage to soil results from induced erosion or soil surface exposure to rainfall and runoff. Roads and firelines or breaks can be designed or located so as not to become channels for soil washing nor sources of windblown materials.

Hand clearing should be limited to as small an area as possible during fireline construction. A mulch could be placed on the site in addition to an appropriate amount and type of fertilizer if critical soil conditions exist.

In the process of using fire to change vegetal cover, a number of soil-conserving provisions should be followed. Burn, or permit burning, when soil moisture, relative humidity, and air temperatures are favorable. The burn should be effective in removing the unwanted vegetative, but fire intensity and duration should be such that great damage is not done to the soil mantle.

Prescribed fires have built-in precautions to prevent undue soil and vegetation disturbance through carefully planned use of equipment or by controlling intensity of the burning.

Road alignment and design and the construction of fire management facilities have important effects on erosion, and control must begin in the design phase, since the location of facilities determines to a large degree the amount of erosion that may occur. The selection of the corridor provides the opportunity to place facilities in favorable relationship to topography, drainage ways, soils, other natural features, and present or anticipated manmade features in order to minimize the base erosion potential. Some further mitigating measures can be stated: (1) Clearing and grubbing should be conducted so as to minimize the area of soil disturbance. (2) The total length of road cut should be minimized. (3) Areas of bare soil exposed to erosion should be shaped to minimized storm runoff. (4) The procedures for erosion prevention in stabilization

efforts should include soil sampling for fertility, erodibility, and texture; correlation of results with the general soils survey; formulating mixes for fertilizing, seeding, mulching, and slope dressing (generally topsoil); and provisions in design for any special problems.

The construction of firebreaks, firelines, or roads on permanently frozen ground in the taiga forest could cause erosion and stability problems since the upper few feet of permafrost may thaw in the summer time. This active zone frequently becomes a soft, soupy quagmire. Roads laid on permafrost fail and settle when the active zone softens. Permafrost can be covered with an insulating blanket to minimize thaw, or subgrades can be placed below the active zone to avoid movement, or the soil in the active zone can be replaced with a non-frost-susceptible material like gravel or coarse crushed rock.

In the maintenance of firebreaks and roads, surface drainage can be retained by performing proper maintenance grading and shaping by patching and filling holes and irregularities. The surface should be kept smooth, firm, and free from excess loose material.

Erosion repair methods on protection breaks and roads are comparable to measures taken in preventing erosion in the construction phase; however, a few variations do exist. Straw or hay, or other suitable substances may be discanchored to lessen the impact. Hydromulch should be used on high steep slopes, rock overburden areas, or areas where the pulp is needed to "plaster" the seed and fertilizer in place. It can be applied with a hydroseeder along with seed and fertilizer. A wood excelsior blanket is recommended on slopes steeper than 35 per cent and longer than 25 feet.

Riprap (usually field stone) is effective for erosion control in culvert scour holes, on shorelines slopes for protection from wave action, and in the lining of waterways and channels. Soil compaction and surface disturbance may be minimized by operating stabilization equipment during favorable weather and soil conditions.

Salvage logging practices should not be carried out on slopes where the potential for excessive erosion mass wasting exists. Factors affecting slopes stability which should be considered include slope gradient, thickness of the remaining soil mantle, character of the underlaying bedrock, precipitation patterns, and the inherent strength of the soil. Tractor logging should be limited to slopes with gradients of less than 35 percent regardless of the potential of the soil for compaction. Tractor skidding should be limited to those seasons and sites where soil moisture is low enough to avoid rutting or gouging of the soil. Operators should not be premitted to clear a skid road for one or two trees. Since jammer yarding requires a closely spaced network of roads, adverse impacts can be reduced by confining these operations to existing road systems; i.e., if new roads must be constructed, alternative logging methods should be used. In some instances jammer yarding may be accomplished by building roads on the snow. In steep topography, aerial systems should be used wherever feasible, particularly on areas ofunstable soils. Landing should be located so as not to

create excessive sidecast or slope stability problems. On highly producted sites, topsoil should be stripped and stockpiled.

INCREASED COMPACTION AND REDUCED WETTABILITY AND INFILTRATION

Soils that have a high potential for compaction by heavy equipment even during the dry season should be excluded from firebreak activities. Coarse-textured soils should have firebreaks planned for seasons when the soil moisture is low enough to reduce soil compaction. Heavy equipment should be kept out of areas with high soil moisture to avoid creation of gouges and ruts. Heavy equipment should be used in such a manner that soil compaction and movement are minimal. Firelines can be ripped to loosen compacted soil if the line also served as a trail for vehicles. Following salvage logging, landings, temporary roads and other intensively used sites may have to be ripped to mitigate soil compaction. Finally, stockpiled topsoil can be distributed over the site followed by seeding.

Measures to reduce fire intensity will lessen the impacts of reduced wettability and infiltration.

LOSS OF ORGANIC MATTER

Fire prevention actions, such as reduction of accumulated fuel and construction of firebreaks, taken to reduce the hazard of severe fires, are designed to reduce the adverse impacts of fire and fire suppression. Loss of organic matter is reduced by restricting the size and severity of fires. The lower surface temperatures during subsequent fires minimize the destruction of organic layers. Replacement of organic matter, with seeding and planting, as needed, on abandoned fire-campsites, firelines, etc., is frequently possible.

Prescribed fire should not take place on shallow or erosive soils when conditions are such that a "hot" burn will consume all the litter layer.

WATER

INCREASED STREAM TEMPERATURE, SEDIMENTATION AND NUTRIENTS

Reduction in size, intensity, and duration of fire resulting from presuppression-prevention activities will modify impacts on water.

Protection and maintenance of vegetation along streambanks are measures taken to avoid increasing water temperature and sedimentation.

The impact of prescribed fire on water quality can be minimized by reducing the temperature of the burn and by reducing overland flow from the burned area to the stream channel. The temperature of the burn may be reduced by scattering the fuel and/or burning under conditions

that preclude high ground temperatures, such as burning immediately after a short rain shower. Overland flow from the burned area may be reduced by completely covering the control line, following burning, with the vegetative material that was removed during construction of the line, and by waterbars or check dams along the control line. Filter strips of undisturbed vegetation left along the bottom of the area burn will filter some of the suspended solids from overland flow (U.S. Environmental Protection Agency, 1972). These filter strips also reduce the velocity of flow and cause deposition of sediment before it reaches the stream.

The mitigative measures employed in prescribed fire, as described earlier, also apply to burning out and backfiring.

CONTAMINATION FROM RETARDANTS, HERBICIDES AND FERTILIZERS, AND PETROCHEMICALS

The potential adverse impact of fertilizer on the water resource may be reduced by the same precautions as with herbicides; that is, strict attention should be given to streamside buffer strips and caution should be used in storing, loading, and applying.

In chemical hazard-reduction practices, the proper combination of chemicals, carrier, method of application (ground or aerial), droplet size for spray applications, and width of streamside buffer strips should be carefully evaluated to minimize the probability of accidental drift onto streams, lakes, marshes, and estuaries. Air stability is essential for aerial applications and these practices should be discontinued immediately when it appears that significant lateral drift may occur.

Methods and areas for chemical mixing, storage, loading, and cleaning of equipment should be carefully selected to minimize the chance of leakage of chemicals into streams, lakes, reservoirs, marshes, and estuaries. Empty chemical and carrier containers should be disposed of carefully. Monitoring of streams and bodies of water should be done prior to, during, and after chemical application to assure safe application.

Generally, the considerations and guidelines for herbicide application apply to fire retardants. However, the firefighter has little control over the time or the place. The most important guideline for fire retardant use is avoidance of surface waters in the application pattern (U.S. Environmental Protection Agency, 1973). Unless the ammonium sulfate and diammonium phosphate are accidentally applied to streams or lakes, the hazard to the water environment is rare. Normal use of these fire retardants consists of dropping them from a fixed-wing aircraft ahead of the fire, in an inverted V pattern, at or beyond the crest of a ridge. Dropped at this location, the rate of spread of the fire is slower, fire fighters are more effective, and the distance from streams is usually so far that pollution is minimal (U.S. Environmental Protection Agency,1973).

STREAMBED AND STREAMBANK CHANGES

The adverse effects of firebreaks and firelines on streambed and streambank may be reduced by: (1) keeping machinery out of stream channels, both perennial and those that carry water during seasons of high runoff; (2) avoiding areas where slope instability will be increased by the removal of shrubs, tree stumps, and roots; (3) avoiding the disruption of the normal distribution of water downslope; and (4) constructing firelines along contours. Areas of thin soils that can be easily stripped from underlying bedrock should be avoided.

The adverse effects of salvage logging may be mitigated by providing streamside undisturbed strips of adequate width and density to reduce or eliminate sediment-laden overland flow from reaching stream channels. All perennial streams and those streams that carry water during peak runoff seasons should have buffer strips. The width of the buffer strip necessary to meet these objectives should consider the slope of the ground into the stream channel; topographic shading of any remaining unburned vegetation; stream characteristics (width, depth, and flow velocity); and the erodibility of the soil.

Salvage logging slash, cull trees, stumps, and other logging debris should be properly disposed. Observations in western Oregon and Alaska have shown that logging slash left in steep intermittent stream channels contributes to the potential for destructive debris avalanches down these channels when soils become saturated during the winter season (Bishop and Stevens, 1964). It is extremely important that debris be removed from these channels concurrent with salvage logging in the area. Channel clearance should not be defered until just before the salvage sale contract is terminated.

Falling timber upslope or along the contour of steep slopes will prevent felled trees from shoorting downhill and into, or through, streamside buffer strips. Trees cut selectively adjacent to natural waters should be felled directionally away from the water. Logging slash and debris that enters stream channels or lakes unavoidable during falling operations should be promptly removed.

A good logging plan is an effective means of mitigating damage to natural waters. Written into the salvage sale contract, the logging plan should stipulate how falling and bucking shall be done and also the logging method to be followed.

Tractor skidding should never be permitted down or across any stream channel, perennial or intermittent. Tractor skidding should be limited to those seasons and sites where soild moisture is low enough to avoid rutting.

Adverse impacts of road construction may be mitigated by designing the roads to minimum dimensions for the proposed use, consistent with traffic safety. If it is necessary to traverse short sections of unstable terrain, remedial measures (riprap, extra drainage, etc.) should be included in the road design. Care should be exercised to protect stream channels and banks by streamside buffer strips wherever possible. In the case of roads that approach stream crossings in narrow V-shaped canyons, the right-of-way clearing width may need reduction below the road to provide a vegetative strip for stream protection. The stream crossing itself should be as narrow as possible, consistent with traffic safety. The stream channel should never be used as a disposal site for excavated material from other portions of the road; often stream crossings become unacceptably wide because of this practice.

The excavated material should be endhauled if this will avoid long sidecast fills in steep terrain. Disposal sites for endhauled material should be selected with care to avoid overloading slopes and causing mass failures. Fills should be compacted if this practice will contribute to slope stability and prevent road failures.

Culverts should be installed at frequent intervals to assure that the road subgrade will remain dry and stable. Drainage from culverts should never be allowed to fall on unprotected fills. Aprons should be installed on fills under culvert outfalls. Downspouts or other suitable conductors should be used to carry culvert drainage and to dissipate the kinetic energy of this water before this is allowed to run onto natural slopes.

Bridges and culverts should be constructed and installed so that the streamflow is optimum for completing the required work with minimum degradation of streambanks and channels. Activities should be planned so that heavy equipment spends the minimum amount of time in the stream channel. All activities necessary for construction and installation should be planned and executed so as to result in the minimum amount of channel disruption and water quality degradation.

INCREASED RUNOFF AND PEAK FLOW OF STREAMS

Presuppression activities to prevent fire impacts by reducing the hazards will maintain conditions for normal water runoff, and peak flow will be moderated.

Erosion control measures should be applied where necessary to prevent surface runoff from carrying sediment and debris into natural waters. Waterbars and check dams should be installed in firelines to divert surface runoff and to reduce its velocity.

The burned and suppression-damaged area should be revegetated with suitable plant species as soon as possible after the fire is out.

CHANGES IN SALINITY

Soluble salt content and turbidity are often directly associated with sediment load, and respond in proportion. All measures taken to reduce soil erosion, stream sedimentation, and contamination from chemicals potentially lessen the impact on water of changing salinity.

AIR

REDUCE QUALITY THROUGH INCREASE OF POLLUTANTS

Troublesome smoke from prescribed fire practices can be mitigated by integrating burning schedules with weather reports so as to produce as fast and hot combustion as practicable (Hall, 1972). More intensive utilization of felled timber holds promise for future abatement of the smoke problem.

The adverse impacts of prescribed fire and of plant removal (hazard reduction) upon local climatic factors are decreasing in magnitude as more knowledge is made available by research and is applied to field operations.

In situations where prescribed fire or plant removal is essential, their adverse impacts on microclimates may be non-existent or insignificant. If considerable impacts are anticipated, impacts may be reduced by keeping small the areas to be treated. If a light burn will achieve silvicultural objectives, its application can be timed for a period when burning conditions will favor an easily controlled fire of low intensity. Fire equipment and manpower can be put on standby status for emergency use if burning conditions should change or if the fire escapes. It will often be necessary to build a fire trail around the project area before treatment begins.

The adverse impacts of burning out or backfiring on microclimates can be mitigated by the same measures as those used for area burning by: (1) keeping the burning area as small as feasible, consistent with the objective of controlling the wildfire; (2) burning, if possible, when burning conditions will favor easy control; (3) safeguarding the burn by burning from a road, fire trail, or natural barrier; (4) maintaining adequate manpower and equipment on standby; and (5) revegetating the burned area with suitable species as soon as possible.

The effect of firebreak of fireline clearing on the local climate can be reduced by keeping the width of clearing as narrow as possible, consistent with safety and fire management objectives. No effective measures are presently available to reduce the short-term degradation of air quality by the emission of internal combustion engines used during fire management activities. Dust arising from vehicles and helicopters may be reduced to some extent by watering or by using portable heliports.

On dirt or gravel-surfaced roads, fire camps, and heliports, periodic application of water effectively reduces the dust pollution.

The amount and kinds of emissions from burning wild land fuels are mitigated by the proposed fire management program. The emission characteristics of fire management activities have been covered in part III. Where these emissions are smoke from prescribed fire or from hazard-reduction burning, impacts of such smoke on air quality are mitigated by a management procedure, i.e., prescribed fire and smoke management plans.

VEGETATION

REMOVAL OF OR DAMAGE TO VEGETATION

Destruction of vegetation can be partially mitigated, or at least it usually can be replaced over a period of time. Short-term adverse impacts include removal of vegetation during the construction of fire camps, heliports, etc.; removal of trees to minimize aerial fuels; and loss of vegetation due to burning out or backfiring. Fire prevention (hazard reduction) and postfire activities, such as replacing topsoil and organic matter and seeding, offset the adverse impacts of fire suppression.

Mitigation of adverse short-term impacts as a result of fire management practices that destroy existing vegetation may be achieved by confining practices to small areas of land, e.g., firebreak construction in strips or patches.

In order to minimize the short-term impact of firelines, backfiring, and burning out, as little vegetation as possible should be destroyed, without jeopardizing the objectives of the actions. When feasible, firelines should be constructed along contour lines to minimize the indirect impact of erosion on vegetal life and growth. Disturbed areas should be artifically revegetated when natural regeneration cannot be reasonably expected in a short period of time. Most of the practices associated with fire management are in themselves mitigative since they are primarily aimed at improving the health and vigor of the vegetation.

Mitigation of adverse impacts resulting from salvage logging is primarily a matter of ensuring that the cutting practice used is one that will result in environmental conditions favorable to tree regeneration on the specific site in question.

Adverse impacts of salvage logging on aquatic plants can also be lessened by use of a buffer strip between the cutting area and stream. Removal of trees, slash, or large debris that reach the stream, or its vicinity, during the logging operation is also an effective measure.

In general, adverse impacts caused by fire breaks, protection facility and road construction can be decreased by locating such activities so as to avoid sidecasting.

Adverse impact of firebreaks, prescribed fire, facility and road construction on aquatic plants can also be mitigated by leaving a buffer strip of heavy or dense vegetation along streams. Other effective measures include, location of road or burn boundary away from the aquatic habitat or areas of unstable soils, engineering of roads to prevent sidecasting, water barring unsurfaced (dirt) roads or firebreaks, and stabilizing roadside cuts and fills and culvert installation points by seeding herbaceous vegetation.

Adverse impacts from road or firebreak maintenance actions can be lessened in severity by hauling soil and debris from landslides to suitable disposal sites, and leaving an effective buffer strip between roadside spraying areas and the aquatic environment.

REDUCED SITE PRODUCTIVITY DUE TO MECHANICAL EQUIPMENT ACTIVITY

Heavy ground equipment should be used carefully in order not to materially degrade the soil-vegetation complex. For example, limit use of tractors where potential exists to damage permafrost layers in the tundra, taiga, or in similar problem areas.

Impacts due to mechanical equipment activity are also discussed in part IV in the section "Soil" under "Accelerated Erosion" and "Increased Compaction and Reduced Wettability and Infiltration."

Specific practices for mitigating adverse impacts on soil are also applicable to vegetation.

Preplanned alternative suppression techniques are considered in the fire suppression plans in order to achieve minimum disturbance of soil and plant cover. For example, aerial fire suppression practices may be used instead of heavy ground equipment.

LARGER, MORE INTENSE FIRES DUE TO FUEL ACCUMULATION

The presuppression-prevention practices are specifically designed to remove hazardous fuel accumulations through mechnical or chemical practices or through prescribed fire.

WILDLIFE

Direct loss of life may occur in hazard reduction, facility construction, fireline construction, backfires, and under prescribed burning. Adult individuals of most species can avoid destruction except under extreme situations (Leopold, 1933).

Mitigating measures include: Avoiding use of prescribed fire during the peak nesting period, inspecting construction areas before commencing work in order to avoid needless destruction, and avoiding sites where young animals are most likely to be concentrated. Where applicable, specific stipulations can become part of the job plan. In all cases except for rare species or those that are relatively immobile and of restricted habitats, these direct losses are temporary and should soon be replaced naturally. Losses caused by activity in suppression of a wildfire ordinarily would be minor compared to losses in the fire itself.

DAMAGE TO AQUATIC LIFE DUE TO RETARDANT TOXICITY

Direct loss of fish retardants (Borovicka and Blahm, 1974), herbicides, and other chemicals can be avoided by keeping the materials out of streams and other waters. Application or accidental discharges into water should be avoided by establishing precautionary measures. If fish populations are eliminated, they should be replaced with appropriate hatchery stocks.

DESTRUCTION OR DEPRECIATION OF HABITAT

Loss of habitat by removal of vegetation ususally is temporary and localized in its effect, in special cases (e.g., rare or endangered species). These losses may occur by burning to reduce the fuel hazard, by constructing firelines and protection facilities, or by setting backfires or prescribed fires. If burning is conducted over extensive areas, mitigation measures should include leaving strips and islands of unburned vegetation for cover and, if needed, by some selected seeding or planting to replace losses. Special consideration should be given to habitats of rare or endangered species. Salvage logging with its road network and snag removal causes some long-term habitat loss. Most of the roads, landsing, etc., can be closed and seeded. Some snags should be left standing where safety regulations permit.

Adverse impacts from hazard-reduction snag felling can be moderated by reserving high-quality snags (with regard to wildlife use) in selected locations. Eagle and osprey nest tree preservation sites should also include adjacent dead trees and snags used for perching by both the young and adults. Preservation of snags, flattops, spike tops, and other dead and dying trees used by wildlife considered endangered should receive highest consideration. If important snags or dead trees cannot be saved, some live trees on the site of future wildlife use can be girdled.

Another type of habitat loss is the quality change occurring in vegetation over a long period due to natural plant succession in the absence of fire. Vegetation has developed along with naturally occurring wildfires, resulting in a pattern of diverse habitats to which wildlife has become adapted. Suppression of natural fires tends to result in extensive homogeneous stands of vegetation. Prescribed burning lessens this trend.

Loss of aquatic habitat can occur when chemical pollutants or excessive amounts of debris (such as from salvage logging) enter the water. Mitigation of these impacts are discussed in part IV under "Water." Loss of streambank vegetation usually can be avoided; if not, it can be replaced by protection and/or seeding and planting practices. If anadromous fish use a stream, it must be kept clear of blockage from fallen trees and damaged culverts.

Other potential measures to soften adverse impacts on aquatic wildlife include: stabilization of all disturbed areas with fast-growing hebaceous plant species of good soil-holding characteristics, removal of all temporary structures from streams, careful removal of fills at stream crossing rather than allowing high water to carry soil away, and use of sediment and debris traps.

INCREASED HUMAN ACTIVITY

Human disturbance due to presuppression-prevention, suppression, prescribed fire, and postsuppression fire activities of various work crews, aircraft, and equipment is largely temporary and local in its effect. The impacts can be reduced by applying reasonable control to minimize the disturbance.

DOMESTIC LIVESTOCK, WILD HORSES AND BURROS

LOSS OF FORAGE

The primary adverse effect of fire management on livestock or wild horses and burros results from the temporary loss of grazing forage traditionally utilized by the animals and disturbance of the animals caused by fire management activities. The loss of grazing areas can have at least two adverse effects: economic loss to ranchers who must make untimely livestock sales or purchase replacement forage and/or overstocking of alternate grazing areas by the addition of the displaced livestock. Deferment of grazing to allow rehabilitation of a wildfire will likely cause serious disruption of domestic animals because of the difficulty of finding, on short notice, alternate grazing areas that are not already utilized to capacity.

If possible, move displaced livestock to alternate public grazing areas for the period of time needed to allow rehabilitation of the burn. If alternate public grazing areas cannot be provided without overstocking the range, require the affected livestock operation to reduce numbers or seasons of use to the extent necessary to prevent overgrazing.

Wild horses and burros, unless restricted by barriers, will forage on adjacent ranges. If, as a result, overgrazing appears likely, adjustments in numbers or a supplemental feeding program would be possible mitigating measures. The construction of fences during post-suppression can disrupt the natural movements of wild horese and burros and cause injury or death if, for example, a wild herd was prevented

from drifting from snow country. Plan protective fences and facilities around burned areas so vital animal movement patterns are not disrupted. Consider the desirability of removing the fences after rehabilitation is completed.

INCREASED HUMAN ACTIVITY

Domestic livestock, wild horses, and wild burros will be disturbed by human activity primarily during suppression and postsuppression periods. Potentially more serious is the problem caused by improved access into formerly remote wild horse habitat areas. These two impacts can be mitigated by controlling human activity and by closing the improved access through legal or physical denial of the area to motorized vehicles.

DAMAGE TO RANGE FACILITIES

During large suppression actions, equipment will damage range improvements, especially roads and fences. Also reservoirs, springs, wells, and other water facilities may be damaged. These impacts can be mitigated by repairing the range facilities in the postsuppression activity.

HUMAN USE AND INTEREST VALUES

HAZARD TO PERSONAL HEALTH AND WELFARE

Accidents and injuries involving fire management activities can be reduced by ensuring that employees receive adequate safety training, that they are thoroughly trained and qualified in their jobs, that they use required safety clothing and equipment, and that they use the proper equipment, maintained in a state of good repair.

If chemicals are used, for example, in postsuppression rodent control on seedings or plantings, health hazards can be avoided by using approved materials at minimum rates, safety training of the applicators, and by following all specifications and guidelines for their application.

Ill effects on inhabitants caused by smoke from hazard reduction and prescribed fire can be mitigated by burning on days when atmospheric conditions favor rapid rise and dispersal of smoke. All such burning should be done in accordance with a smoke management plan.

CHEMICAL CONTAMINATION OF WATER SUPPLY

Avoid contamination of water by keeping use of chemical away from streams. Refer to discussion in part IV on chemical contamination under "Water," subsection "Contamination From Retardants, Herbicides and Fertilizers, and Petrochemicals."

IMPAIRED VISIBILITY DUE TO DUST AND SMOKE

Atmospheric dust arising from fire management activities can be reduced by watering roads and heliports.

Mitigation of dust and smoke emission impacts is discussed in part IV under the heading "Air."

DISTURBANCE OF AESTHETIC VALUES

Visual impacts may be reduced by several measures. The appearance of smoke in the atmospheric from prescribed fire may be minimized by smoke management technology. This involves the coordinated effort of meteorologists and public and private agencies to integrate burning schedules with weather reports so as to produce rapid fuel combustion and quick dispersal of smoke into the upper atmosphere (Hall, 1972). Alternative hazard-reduction measures that create no smoke may be feasible; e.g., chipping or burying slash.

The adverse psychological effects created by highly visible fire management activities can be greatly reduced by skillful, perceptive use of landscape management techniques. On gentle terrain, a buffer strip of uncut trees and undisturbed ground cover may be reserved to screen aesthetically unpleasant activity in foreground distance and middle-ground distance zones from the view of sightseers. Where firebreaks or firelines will be visible in middle-ground distance and background distance zones, negative psychological effects can be mitigated by avoiding straight-cut edges and regular shapes, by locating lines along contours so as to conform with topography, by blending firebreaks or lines into natural vegetative features, by keeping middle-ground lines narrow, etc. Landscape management can also do much to redue the unsightliness of scars on the landscape and to visually close unnatural openings created by fire suppression.

Cleanup of unsightly solid waste resulting from fire management operations, primarily from suppression practice, is required.

Where scenic values are high, prescribed fire should be used at the beginning of the rainy season or just before the growth period begins, to minimize the length of time blackened ground will remain on view.

LOSS OF OR DAMAGE TO GEOLOGICAL, ARCHEOLOGICAL, AND HISTORICAL FEATURES

Identification and designation of unique geological formations in land use plans is the foremost mitigative measure available to preserve their human interest values. Fire management activities should be planned and executed to prevent damage to such formations. Firelines, firebreaks, and roads should be kept away from such formations.

No fire management activities that would disturb or otherwise affect archeological sites should be allowed in their known vicinity.

Firelines, firebreaks, and roads should be kept away from undisturbed sites. New finds should be reported to the appropriate Federal and State agency having responsibility for investigating and evaluating archeological sites. Contractors and their employees should be made aware of known sites in their areas of operation. Fire suppression may be deemed necessary if the site is combustible and threatened, such as a ghost town.

Fire management activities in the vicinity of historical sites should be planned and conducted to avoid both physical and visual damage. Firebreaks, firelines, and roads should detour around or away from them. Contractors and their employees should be instructed to avoid damaging historic sites. Fire suppression may be deemed necessary if the historic site is combustible and threatened.

Where there is potential for the existence of archeological, historical, and cultural sites, a field survey will be completed by a professional archeologist who can then evaluate the impacts of potential fire management practices.

Litter and other materials, remaining after fire activities, should be removed as soon as possible.

All prescribed fires should be monitored and suppressed if impacts on human interest values will be adverse, such as when the fire threatens newly discovered cultural values within the prescribed fire area.

DAMAGE TO PRIVATE PROPERTY

During the suppression action on a wildfire some damage to private property may occur because of the nature of the emergency action and time restrictions. This damage (e.g., broken cattle guards, broken fences, firelines, abnormal wear and tear on roads, and water supply facility damage or depletion) usually is minor. This damage can be mitigated through the presuppression and postsuppression activities. Through the identification of private property in presuppression-practice planning, many problem areas can be avoided. Any damage to private property occurring during the suppression action can be mitigated during postsuppression by rehabilitation of damage.

Through prescribed burning and hazard reduction in adjacent areas, the danger of a raging fire later threatening human life and destroying or damaging private property, especially near urban areas and heavily used areas, can be minimized.

DISRUPTING LOCAL LIFESTYLES

During presuppression-prevention, postsuppression, and prescribed fire activities, the impact prescribed fire activities, the impact to local lifestyles will be minor. These activities are preplanned and concern only a few people and small quantities of equipment. These types of activities effect local lifestyles and can be mitigated through planning and an information and education program.

During suppression activities, the impact to local lifestyles will be moderate to severe, depending upon the magnitude of the suppression action, its proximity to a community, and the size and type of community. This can be partially mitigated by preattack planning; avoidance of communities, if possible; and coordination with local government and/or officials.

Mitigation of impacts on cultural, ethnic, and religious groups can best be accomplished through understanding and adherence to civil rights laws and regulations pertaining to employees of the Federal Government or its contractors. Cultural groups should be encouraged to participate in the development of land use plans. Avenues of communication should be cultivated and used.

HUMAN PRESENCE

The noise accompanying human activity in any phase of fire management is temporary, and can be only partially mitigated. Where necessary, as in the vicinity of campgrounds, presuppression and postsuppression activities can be timed to avoid the height of the recreation season. Mufflers, which aid in noise abatement, are required on all types of fire equipment. The level of noise produced by fire management activities is not generally injurious to personal health, and may be placed in the category of a nuisance.

Solid waste could be a major pollutant resulting from fire management activity. Wastes arise from such items as discarded petroleum containers, food wrappers, and kitchen and sanitary wastes. The major control mechanism for these pollutants is to provide adequate disposal facilities and require their use. Collected solid wastes can be removed and disposed of at authorized disposal areas and useful materials can be salvaged and recycled.

Prescribed burns should be timed for the least possible interference with seasons of heavy recreation activity.

UTILIZATION OF SCARCE PETROLEUM PRODUCTS

The fire management program will utilize petroleum products. All types of products will be consumed; e.g., gasoline for saws, pumps, aircraft, and vehicles; jet fuel for aircraft; greases and oil for all types of equipment; diesel fuel for heavy equipment; and kerosene for firing devices. This impact can be partially mitigated by timely planning and effective utilization of all types of fire management equipment, but moreover by the implementation of fire management practices that are less dependent on such products.

DESTRUCTION OF OR DAMAGE TO NATURAL AREAS OF SCIENTIFIC, EDUCATIONAL, OR WILDERNESS VALUE

A large-scale human infringement related to fire activities within wilderness and natural areas should be minimized by carefully preplanning practices and actions that will be taken.

These types of areas are identified during presuppression, preattack planning, and are mitigated by management's and public input into this planning.

DISRUPTION OF LAND AND RESOURCE USES

During hazard reduction, suppression, and prescribed fire, land is removed from resource production through the construction of roads and facilities, firebreaks, and firelines. The impacts of firelines and some types of firebreaks can be mitigated and the land returned to traditional resource protection roads and facilities; some firebreaks cannot generally be returned to their former use and, therefore, this impact cannot be ameliorated.

Recreation land use can be disrupted by smoke from hazard reduction and prescribed fire. This can be made less severe by burning during nonpeak recreation activity and by following a smoke management plan.

Recreation land use can be temporarily affected by a prevention practice called "area closure" during periods of high fire danger. This practice assists in reducing the probability of man-caused fires. This practice is only used as a last resort and the impact on direct human uses such as recreation, will occur notwithstanding. While a strong public information program can explain the problems and reasons for closures, such a program cannot eliminate the impact.

Noise from all fire management activities can cause temporary disruption in wildlife, recreation, livestock, wild horse, and wild burro traditional land uses. This impact can be partially mitigated through avoidance of key areas. Since presuppression-prevention, post-suppression, and prescribed fire activities are preplanned and the noise levels are low, the associated noise impact will be minor.

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PART V

ADVERSE EFFECTS THAT CANNOT BE AVOIDED

This part discusses the adverse effects and impacts that cannot be eliminated. It includes a discussion of the relative value placed on the impacts and who or what is affected.

SOIL

Soil compaction, reduced wettability, and loss of water infiltration, resulting from use of heavy equipment or from small areas of intense fire management activities, cannot be fully mitigated. These effects are generally short term.

Soil disturbance and accelerated erosion from firebreaks, firelines, road and facility construction cannot be fully mitigated even when proper, timely rehabilitation practices are performed. Such erosion resulting in short-term site deterioration and lessened water quality endures until mitigating actions are fully effective.

Intense burning, such as slash piles, will result in short-term minor decrease in soil organisms.

Organic matter loss will result if fire intensity is severe or abnormal rains occur prior to completion of rehabilitation practices.

Whenever chemicals or herbicides are used there will always be some residue left in soil regardless of the mitigating measures taken in the process of application or in subsequent rehabilitative actions. Such measures are usually effective only in restricting impacts to the smallest feasible onsite area.

In general, the amount of unavoidable damage depends on soil types, amount of soil disturbed, burn intensities, topography, subsequent rainfall intensities, etc.

WATER

Streambed and bank changes resulting from fire management actions can be largely mitigated if rehabilation is started immediately and heavy rains do not soon occur. While heavy channel erosion may be avoided, the sedimentation already existing will persist.

Short-term contamination from changes in salinity, sedimentation, nutrients, and temperature increases cannot be avoided where intense fires have burned along streams. Any fire activity using the streams for control purposes or not leaving adequate filtering vegetation will result in short term contamination.

Short-term contamination from retardants and herbicides will occur because of accidents, wind shifts, unplanned delays in rehabilitation, and heavy rains.

AIR

Short-term air pollution from backfires and burnouts performed during suppression is unavoidable.

Pollution also exists in hazard reduction and prescribed fire actions, but adverse effects are minimized through smoke management practices.

Dust and engine emissions from aircraft equipment operations are largely unavoidable, insignificant, short-term, polluting impacts.

VEGETATION

Increasing fuel accumulations due in part to a successful fire suppression program are mitigated only in part through hazard reduction and prescribed fire practices of a fire management program.

Areas under strict protection in which no fire can be tolerated will eventually have large fuel buildups. Such areas of high fuel accumulations will increase the risk of larger, more intense wildfires; these, in turn, will require more sophisticated and costly fire prevention and presuppression practices. Loss of fire-dependent animal and plant species will occur, resulting in a less diverse life form.

Removal of or damage to vegetation during the course of fire activities is largely unavoidable, but is an acceptable compromise to the larger adverse impacts when fire threatens man's investments.

Poorer seedbed conditions in protection areas result from fire exclusion. Mineral soil is not exposed because of accumulating organic litter that also locks up nutrients, permitting very slow release to plants. This can lead to rapid deterioration of a vegetal type over the long term, especially in fire-dependent types which need periodic recycling of nutrients in order to maintain long term productivity.

WILDLIFE (INCLUDING AQUATIC), LIVESTOCK, WILD HORSES AND BURROS

Displacement of animals from normal habitat usually results from postfire rehabilitation practices; e.g., fencing rehabilitated areas. This is a short-term adverse impact and unavoidable if area is to be restored to full use--a long term benefit.

Short-term loss of existing forage is an unavoidable impact of fire management activities.

Decreasing quality and variety of fire-dependent habitat is a long term impact of fire exclusion.

Loss or injury of animals is ordinarily not a serious factor in fire management. Such losses cannot be fully mitigated. There are cases where destruction of a limited specialized habitat may occur (e.g., snag falling). This could seriously deplete endangered species.

Noise of aircraft, noise of equipment operation, and human presence have unavoidable (though not usually serious) impact on animals.

HUMAN INTEREST

Prescribed fires temporarily and in varying degrees blacken the landscape creating an unavoidable but short-term aesthetic impact.

Geological, archeological, or historical features can be unavoidably lost or damaged if their existence is unknown prior to fire management activities, or through accidental disturbance.

The suppression activities during emergency conditions can damage natural areas of scientific, educational, or wilderness value. The larger the fire and the more extensive the suppression action, the greater is the opportunity for unavoidable adverse impact.

Impaired visibility due to smoke from burnouts, backfires, and prescribed fire may interfere temporarily with recreational use.

High noise levels produced by engines of aircraft and other equipment cannot be fully mitigated.

Temporary closures of areas because of hazardous travel conditions is a fire management practice and unavoidable.

The impact of local lifestyles during the suppression program cannot be fully decreased.

Accidents resulting in injury and occasional death will occur from fire management mishaps and are an adverse impact.

The temporary adverse psychological effects created by highly visible fire management activities can only be ameliorated.

There will be some unavoidable impacts on cultural and ethnic values as a result of large fire suppression activities:

- Cultural--large fires require suppression crews, amounting to an invasion of small communities. Large logistic demands disrupt small supply centers, usually impairing their normal service to local areas. Also, local hiring of personnel, equipment, and services is abrupt and of high priority and may be at different rates than are normal locally; this has post-fire consequences.

- Ethnic--fire crews are made up of all ethnic groups and social strata and may clash with local people during these periods of stress.

OTHER

Certain economic losses that are unavoidable may occur in prescribed burning. For example, all forces to do the job are organized and firing times are set in advance. If the weather changes and the forces must disband, all mustering costs are lost.

The petroleum products used in equipment operation, as well as in all logistical support by air or ground forces, are unavoidably lost.

PART VI

SHORT-TERM USES VERSUS LONG-TERM PRODUCTIVITY

Fire management is a means of protecting human and natural values and enhancing the productive capacity of public lands.

Presuppression-prevention, suppression, postsuppression, and prescribed fire involved short-term practices to obtain long-term benefits. If planned and implemented according to BLM policy and guidelines, adverse impacts, such as the addition of smoke and dust into the air, the disturbance of wildlife, or the temporary blackening of a land area will be short-term.

Some of the long-term effects of fire management that will enhance the state of the environment for future generations are:

- Protection of life, property and resources through well-planned suppression action;

- Improvement of wildlife habitat and livestock ranges through post-fire rehabilitation and prescribed fire practices;

- Reduction of hazardous fuels through prescribed fire or other hazard-reduction methods;

- Rehabilitation of resources and facilities destroyed or damaged by wildfire;

- Increased water yields through alteration of vegetation;

- Perpetuation of plant community successional stages or subclimax vegetation with prescribed fire;

- Improvement of soil and water quality on wildfire-burned areas through postsuppression practices.

SOILS

While some practices may have a short-term detrimental impact on localized areas, most practices will either increase or not affect long-term productivity. The removal of vegetation and organic matter in the course of hazard-reduction and fireline construction could lead to slight reductions in soil nutrition over time. The area occupied by structures and roads will not be productive during the life of the facility. Their possible reclamation along with temporary roads, firelines, and breaks can be expected to result in reduced productivity where extensive excavation was made. The postsuppression rehabilitation practices on

wildfire-burned areas will have both short-term and long-term beneficial effects on productivity through stabilization of soil. The potential for decreased long-term productivity as a result of any management practice that significantly affects the ground cover, such as firelines, is greatest in parts of the tundra, desert, taiga forest, and alpine zones of the montane forest.

In localized areas where massive soil movement and continuing erosion take place, along with the construction of permanent road and facility sites, the long-term productivity of soil micro- and macroorganisms will be affected.

WATER

In those areas where snow-melt forms a significant portion of the season runoff, the increased snowpack that occurs in open areas, such as firelines and breaks and prescribed fire areas, is a definite benefit by increasing water productivity. Where slopes and stream channels are stable, this increased runoff has no adverse effects and suspended-sediment concentrations will remain relatively stable. Periodic erosion along protection lines and roadways resulting from seasonal rains and storms will have a minimal impact on the productivity of the aquatic ecosystem.

The postsuppression and rehabilitation practices on wildfire-burned areas will have both short-term and long-term beneficial effects on productivity through sediment control creating improved water quality.

Measures to mitigate adverse impacts on water quality will help maintain the long-term productivity of aquatic micro- and macroorganisms. However, unpredicted events and accidents caused by fire management practices can have a serious effect on aquatic organisms in small streams for a few years. The effect on long-term productivity of micro and macroorganisms is not known.

AIR

The potential long-term impact on the microclimate of the taiga forest of practices that destroy vegetation and/or cause significant soil disturbance are unpredictable because basic research is lacking. In general, however, fire management program practices do not affect the climate or air as they relate to the long-term productivity of the forest.

Smoke components have average residence times in the air as follows:

CO	- 10 to 36 days
NO/NO-2	- 3 to 4 days
Particulates	- varies by size and composition, but mostly less than 12 hours
Terpenes and olefins	- a few hours

These are shown not to be accumulating in the atmosphere. The 1974 annual report of the Council on Environmental Quality shows that total suspended particulates, including smoke, have decreased at many urban monitoring sites in the 1960-72 period, while no change was noted at nonurban sites.

VEGETATION

Vegetation is a renewable resource, capable of reestablishment on most areas that are denuded during wildfire and during hazard-reduction, fire suppression, and prescribed fire activities. Through natural and artificial revegetation during postsuppression, the former productivity of the site can usually be both restored and increased over time. Productivity, especially, can be increased through fire management practices, i.e., protection from wildfire, salvage logging, and prescribed fire.

WILDLIFE

The use of fire management practices, as a rule, will improve long-term productivity for wildlife. Removal of dense, old, fire-protected vegetation and restoration with varied vegetation mosaics will even enhance such productivity.

DOMESTIC LIVESTOCK, WILD HORSES AND BURROS

Fire management will have no adverse impact on long-term productivity. Long-term productivity is more likely to be increased through protection and prescribed fire.

HUMAN USE

Long-term impacts on human use will vary in the following areas:

- Health and Safety--With the exception of fire-related employee accidents and accidents between the public and fire equipment, there should be no long-term effects associated with the fire management program.

- Wilderness--Assuming that natural or wilderness areas are recognized and classified accordingly, there will be no long-term adverse impact of the fire management program. Natural fires burning under appropriate management guidelines, together with other natural agents such as insects, disease, wind, etc., will generally maintain the natural wilderness ecosystem.

- Recreation--The fire management program will not impair future long-term recreational values, but will protect and maintain them through the use of prescribed fire.

- Grazing--The fire management program will not adversely impact the numbers of livestock, wild horses or burros using the range. Through protection and prescribed fire the range capacity can be increased.

- Timber--The fire management program will enhance and protect investments and increase regeneration and productivity of timbered areas through prescribed fire.

- Agriculture--There should be no long-term effects on agricultural crops or irrigation systems as a result of practices associated with fire management.

- Aesthetics--The program should have no long-term effects on recreation potential.

- Geological Human Interest Values--Any impact that accidentally obliterates or substantially alters unique geological features would decrease their long-term human interest values.

- Archeological Human Interest Values--Accidental destruction or damage to archeological sites caused by the fire management program would have severe long-term impacts on their values. However, fire protection will aid in preserving the long-term value.

- Historical Human Interest Values--Inadvertent destruction or damage to historic sites would have long-term impacts if the sites were not restored. Even with restoration, there would be some diminution in historical value. Protection from fire, however, will aid in preserving the long-term value.

- Cultural, Ethnic, and Religious Values--To the extent that members of a particular culture are affected and changed by contact with members of a different culture, there may be some long-term impact on those individuals.

PART VII

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The proposed fire management program is intended to prevent irreversible and irretrievable resource commitments should the proposed action be implemented. It includes a survey of the unavoidable impacts and the extent to which the action irreverisbly curtails the potential uses of the environment.

Part VII focuses on erosion, destruction of human interest values, elimination of endangered species and their habitats, and the reduction of land in natural resource uses. The consideration of any of these consequences is based only upon the existence of risks residual after the fullest possible mitigation efforts have been employed.

PHYSIOGRAPHY, GEOLOGY, AND MINERALS

Erosive processes induced by removal of the vegetative cover and the construction of facilities, firelines, firebreaks, and roads produce an indeterminable amount of localized mass wasting or mass movements which cannot be reversed or retrieved, no matter what mitigating measures are taken. When the vegetal cover is removed from an area where steep slopes occur and there is an abundant supply of moisture, the erosional process will sustain itself. In those situations where rock types and structure are conducive to weathering, the erosional cycle will increase. Any resulting soil deposition into bodies of water represents a permanent loss of the resource. This is also a natural process which tends toward an equilibrium over geological time, but in terms of man's life results in a disequilibrium because of the time required for the area to stabilize.

SOILS

The irreversible impact and commitment of the soil resource is closely correlated to the physiographical and geological factors described in the previous part. There are additional impacts, however, if the assumption is made that permanent fire facilities, firebreaks, and roads will remain in perpetuity, in which case such soil surface will be committed to a relatively irreversible use. Furthermore, the soil, rock, gravel, and other materials used to construct and maintain the firebreaks, roads, and structures could also be viewed as a permanent commitment of resources. In a theoretical sense, however, firebreaks and roads could be "dismantled," and the areas turned to a productive state if society's values so deemed necessary.

WATER

Watershed values of a drainage are irretrievably committed in those instances where bare rock has been exposed or enlarged as a result of massive soil movements. Landslides can also cause the destruction of a natural stream channel, resulting in its rechannelization, and the

accompanying permanent loss of soil and other materials.

AIR

Under extreme conditions, natural restoration of the original microclimate may take a long time, but there is no irretrievable commitment to any fixed microclimate.

The question of smoke accumulating in the global atmosphere is raised by recorded increases in CO_2 at the rate of about 1 percent in five years. Most scientists agree that this increase results from the combustion of fossil fuels. The combustion of vegetative fuel should not add to this, as the process of decay will emit approximately the same amount. Burning merely affects the timetable for these emissions locally.

VEGETATION

There are relatively no known irreversible or irretrievable impacts of fire management on vegetation except in the case of accidental elimination of endangered plant species. Even where drastic misapplications may occur and result in extensive delays in regeneration, natural plant succession and technical progress can be expected to restore the site to a vegetated condition. Only where landslides expose rock surfaces can the vegetative condition be considered irretrievable. The natural process of conversion of standing water habitats to land masses is accelerated by those fire management practices that contribute to sedimentation.

WILDLIFE

Any loss of endangered species constitutes a potential irreversible and irretrievable commitment. Small, non-mobile terrestrial species with limited habitats and only local distributions are especially vulnerable. Other mobile terrestrial species with widespread distribution could possibly be eliminated from a specific area for a long period of time. The most vulnerable aquatic animals are the rare fishes, and a rare-fish population could be severely damaged and possibly exterminated from an entire river system as a result of a fire management related accident.

DOMESTIC LIVESTOCK, WILD HORSES, AND BURROS

There are no known irreversible or irretrievable impacts of fire management other than accidental direct loss of life.

HUMAN USE

Irretrievable or irreversible impacts of fire management on human use can vary as is evident in the following:

- Health and Safety--Fire-related employee accidents that cause permanent injury or death are, of course, irreversible and irretrievable. This also applies to members of the public injured or killed in accidents involving fire management equipment or aircraft.

- Recreation--The fire management program commits no recreational values to irrevocable loss or degradation.

- Grazing, Timber, and Agriculture--Accidental loss of soil caused by fire management activities can be considered irretrievable.

- Aesthetics--In the long run the fire management program makes no irrevocable impact on aesthetic values. Even old growth forests could be reestablished, although it would take several centuries.

- Geological Human Interest Values--Accidental damage or destruction of geological sites would, within the time-frame of man's interest, be irreversable and irretrievable.

- Archeological Human Interest Values--Inadvertent damage to or destruction of archeological sites would probably be irreversible and irretrievable. Provided sites were not completely destroyed, enough of the site might be salvaged to retain some human interest value.

- Historical Human Interest Values--Conceivable all historical sites, which are the works of man, could be restored should they be destroyed. However, their values would be diminished and, in effect, the values would be lost irretrievably.

- Cultural, Ethnic, and Religious Values--In a theoretical sense, there would be no irreversible and irretrievable loss of cultural, ethnic, or religious values caused by the fire management program on the assumption that people could revert to their original cultures. For all intents and purposes, however, the nature of man is contrary to this assumption and, therefore, where the fire management program does impinge on these lifestyles, beliefs, or values, they must be considered as irretrievably lost.

PART VIII

ALTERNATIVES TO THE PROPOSED ACTION

This part, in addition to describing each alternative, includes a brief comparative description of the proposed action and each alternative and the beneficial and adverse impact of each alternative. For an economic analysis of costs and benefits refer to appendix L. The two alternatives are as follows:

- Total fire control program (Suppress all wildfires)

- Limited fire control program (Allow wildfires to burn-no action)

TOTAL FIRE CONTROL PROGRAM

This alternative emphasizes the prompt suppression of all wildfires to assure minimum area of burn by each wildfire on public lands or fires on lands adjacent thereto that threaten public lands. The fire control policy and operational standards combine fire planning, active prevention, and aggressive fire suppression. Resource values or local habitats are recognized, but are not controlling factors in the operational policy. For a comparison and discussion of the fire control activities and practices utilized in this alternative and others, refer to appendix N.

ENVIRONMENTAL IMPACTS AND EFFECTS

The environmental impacts and effects of this alternative can occur in varying degrees and depend on the degree to which fire impacts the system.

There are differences between fires of early times and fires of today. After nearly 40 years of fairly efficient fire control programs, larger accumulation of fuels exist today. Man himself has been increasingly an accidental ignition source. This requires an ever-increasing technology to keep the fire control program such that management can cope with new and changing fire regime.

The environmental impacts and effects of this alternative are very similar to the proposed fire management program in activities prevention, presuppression, and postsuppression, somewhat similar in suppression. The greatest difference is in the prescribed fire activity; i.e., the beneficial and adverse impacts herein are limited to the hazard-reduction practice.

BENEFICIAL

The beneficial impacts are as follows:

- Reduce the number and size of wildfires

- Reduce difficulties, costs, and damages of future suppression actions

- Reduce smoke production caused by wildfires
- Increase release and availability of nutrients
- Facilitate human and animal access
- Discover archeological and historical features
- Aid in human rescue
- Protect human life and manmade structures
- Protect archeological, historical, and other unique sites and resource investments
- Limit loss of vegetation cover in watersheds
- Limit loss of forage and wood products
- Limit loss of habitat
- Maintain conditions favorable to plant succession
- Provide nutrients from retardants
- Provide temporary local stimulus to the economy
- Protect endangered species of plants and animals
- Reduce soil erosion
- Reduce stream pollution
- Reduce fire hazard
- Restore desired plant species
- Restore habitat and forage for wildfire, livestock, and wild horses
- Inhibit damaging insect outbreaks
- Improve recreation opportunities
- Improve visual aspects of the landscape

ADVERSE

The adverse impacts are as follows:

- Soil: lethal heating of organisms reduces wettability and infiltration; increases soil erosion and compaction, and loss of organic matter

- Water: increases stream temperature, sedimentation and nutrients; contamination from retardants, fertilizers, pesticides, and petrochemicals; streambed and streambank changes; change in water salinity

- Air: reduces air quality through increase of pollutants.

- Vegetation: removal, consumption, or damage of vegetation; increases fuel buildup; long-term loss of life form and species diversity; loss of fire dependant species

- Wildlife (including aquatic): loss of life; destruction of habitat; increased destructive human activity; decrease in plant variety and death or injury to aquatic life due to retardant toxicity

- Livestock, Wild Horses and Burros: loss of forage, increase of human activity; damage to range facilities such as water development and fences; displacement of animals

- Human: hazard to personal health and welfare; destruction or damage to natural areas of scientific, educational, or wilderness value; contamination of water supply; damage to private property; loss or damage to geological, archeological, and historical features; disrupt local lifestyle; disrupt land and resource uses; disturbance of aesthetic values; increase in human presence, noise, and solid waste; impair visibility; utilization of scarce petroleum products

LIMITED FIRE CONTROL PROGRAM

No suppression action on wildfires is another alternative to the proposal. In this alternative, wildfires would be allowed to burn unchecked on the premise that this is how our present environmental complex of vegetative types was established and must by cyclically maintained. Except for the prevention practices aimed at reducing occurrence of man-caused fires, there would be no fire program costs. This limited fire control alternative could be modified through investment in prevention practices which would reduce opportunities or ignition or, if started, reduce intensities and spread of fire. Such practices of closures, hazard reduction, and weather modifications would be found concentrated around areas of heavy investment and high resource value.

The Western States and Alaska have an evolutionary history of fire from lightning and man-caused ignition sources. Frequent fires

tended to reduce fuel accumulations in the forests and rangelands and, since they recurred every few years, they were rarely intense. Thus, a century or more ago, fuel conditions differed from those of today because they were held at a "natural level" by the cyclic pattern of wildfires.

Even the man-caused fires of that time were different because most were set at times and in places best meeting specific objectives, not accidentally with natural wildfires, large accumulations of fuel exist on all lands in the West and Alaska. Large disaster-type wildfires are inevitable.

Today, should wildfires be allowed to burn naturally, they would be both frequent and intense until the vegetal composition and fuel dynamics come into balance with the "new fire regime"--a return toward the former natural level. The difference would be the large and increasing numbers of accidental human-caused fires which are disruptive of the natural cycle. An approximate fuel balance would not be achieved for many decades.

ENVIRONMENTAL IMPACTS AND EFFECTS

The beneficial and adverse impacts and effects of wildfire and the limited fire control program are described below. Wildfires fueled by vegetation may be comparable to a two-edged sword. They have both harmful and beneficial consequences. The harmful aspects are well known. Wildfires raging out of control can trigger catastrophic destruction. On the other hand, wildfires that have some of the characteristics of a prescribed fire will have some beneficial effects.

Fuel loading or the quantity of fuel available for burning is one of the more important factors in assessing potential damage from wildfires. Fuel and fuel weight sets the maximum potential energy that may be released during burning. For a given rate of spread and constant heat yield, the fire intensity is directly proportional to the quantity of fuel that burns (Brown and Davis, 1974).

Two other important factors in assessing potential for damage from wildfires are when and where wildfires burn. Many wildfires today are human-caused and a large percentage of these are of an incendiary nature. These occur in the months of June, July, August, and September when fire behavior factors result in adverse environmental and economic effects. Further, such fires occur in areas where wildfires are difficult to control and are not in the interest of good land and resource management.

There are also many secondary factors that govern the intensity of a wildfire. These include topographic and weather components. The current state of each component, and its interaction with fuel, each other, and with the wildfire largely determines the characteristic behavior and the damages resulting from a wildfire.

There are regional variations in the prevalence of wildfires and the amount of fuel. For example, deserts are characteristically less affected by wildfire than are other areas. The more arid the desert the less fuel is produced and the less frequent and severe are the wildfires that may occur. However, even though wildfire frequency and severity may be relatively low in any rating scale, their effects on the desert ecosystem may be extreme. Another example, in southeastern Alaska, with dense fuels in the coastal western hemlock-Sitka spruce forests from Juneau toward Petersburn, apparently fires very rarely burn (H. Weaver, 1974). Wildfires do not occur in this area primarily because of weather conditions.

Public attitude toward wildfire varies considerably. The general public, landowners, and resource users who reside in areas where wildfires are infrequent are generally not too concerned about wildfire or its destructive forces. On the other hand, in most areas of high resource value with fuel buildups and high ignition risk, the local residents and others are concerned about wildfires. They are especially concerned if wildfires could adversely affect their uses or values such as socio-economic values, property values, forage values, habitat values, recreation values, watershed values, or timber values. Fear of uncontrolled wildfire is a powerful force. It becomes exceedingly important when a wildfire is a threat to human lives and property. It results in a demand for public security from wildfire that may far outweigh consideration based on loss of natural resource values.

BENEFICIAL

The beneficial impacts are as follows:

- Air quality: There are no beneficial impacts of wildfire on air quality.

- Soil: Improvement in soil fertility, lower soil acidity, and exposure of mineral soil improves seedbed.

- Water: Increased runoff may provide a temporary increase in the downstream water quantity.

- Vegetation: Decrease undergrowth, change plant density and composition, increased germination of hard seed coat species, rapid and released growth of remnant plants, remove weaker trees and vegetation, reduction of fuel, and assist in determining rate of plant succession.

- Wildlife: Aid in maintaining biotic diversity needed for most species of wildlife, improve forage and habitat in some instances, destroy rodent and insect populations.

- Livestock, Wild Horses and Burros: Improve forage in some instances.

ADVERSE

The adverse impacts are as follows:

- Air quality: Smoke would cause impaired visibility and lowered air quality due to pollutants. This in turn would adversely affect people and the human environment. The frequent, intense longer-period fires of the natural cycle would make these impacts a summer long experience.

- Soil: Increase erosion; lower ability of topsoil to absorb and retain water; increase potential of soil slump on hillsides; reduce organic matter; cause greater temperature extremes for some time after the fire, thus affecting plant growth; nitrogen is totally lost in the burning process when vegetation and humus are consumed by wildfire; beneficial soil microbes in the thin surface layer are destroyed, site deterioration.

- Water: Decrease in water quality because of sedimentation; increase and larger variations in water temperatures; increase in ash and nutrient content of streams; increase in runoff both overland flow and in water drainage channels which in turn increases the risk of flood hazard and decreased onsite moisture availability.

- Vegetation: Consume, remove and damage to vegetation; loss of nutrients, primarily nitrogen; long-term loss of life form and species diversity, loss of fire intolerant plants, increase in fire tolerant plants; temporary decrease in fuels.

- Animals: The effect of limited fire control on animals is usually more an indirect impact than a direct impact. However, some of the impact and effects include loss of forage and habitat; loss of life; displacement of animals; decrease in quality of forage from perennial plants to less desirable annuals; possibility of creating extensive homogeneous stands of plants which limit the variety of animals.

Human Interest Values: The most severe impacts from wildfire would be on people. In the growth of man and his culture he has placed expedient limitations on natural cycles in order to best meet his short term needs. He has placed developments and other investments throughout the ecosystem and then has tried to prevent wildfires. Should unrestricted natural fires now occur they would make broad disasterous sweeps through the fuel accumulations of the past 70 years, destroying man's investments, crippling resource-related industries, and adversely affecting his general well being. Fifty to 100 years could well pass before the natural level of fuels is regained and the short-term disaster fires again limited in occurrence.

There would be no adverse impacts due to fire suppression activities under this alternative, but the longer burning periods of all fires would create many adverse situations:

- Increased smoke concentrations would be objectionable to all residents, resource users, or tourists by decreasing air quality and visibility;

- Increased threat to geological, archeological, historical, and cultural sites with probable destruction of combustible sites;

- Increased threat to cultural improvements, range, timberlands, and agricultural lands with heavier economic losses a certainty; and

- Increased potential losses of developed recreational sites, isolated ranches of other property.

To summarize the impacts of wildfires:

- Most impacts are short-term in nature;

- Most impacts on air, soil, and water are adverse;

- Most impacts on wildlife are beneficial in the regional aspect, but can be adverse in local habitats;

- Major adverse impacts relate to people--their property, investments, domesticated animals, and both short and long term well-being; and

- Major beneficial impacts relate to the establishment and maintenance of fire dependent and successful vegetal mosaics, providing diverse habitat for wildlife and for man's utilization.

In general, under the limited suppression alternative there would be none of the impacts from suppression practices described in part III. There impacts from the fires would be one of degrees; the larger fire the more intense and wider the impact on the ecosystem.

Were it not for the altered natural fire mosaics and heavy fuel accumulations now existing on most public lands, the impacts of this alternative would not be as adverse. However, man himself has so altered the ecosystem that environmental considerations alone should not dictate fire management policy. Through land and resource development and utilization, man has placed monetary and cultural investments in the path of environmental management. Protection of these investments is demanded by and receives the support of the public. Since these investments are scattered in varying intensities throughout the public lands, the concept of this alternative for long-term environmental concerns cannot be recognized and must be restricted to limited areas if, in fact, permitted at all. A blanket policy of allowing all fires to burn under all conditions is inevitably detrimental to economic and social values (Agee, 1974).

PART IX

CONSULTATION AND COORDINATION WITH OTHERS

Development of the Draft Environmental Statement

The Bureau of Land Management completed a working draft of the fire Management Environmental Impact Statement in August 1975. It was compiled under the leadership of BLM staff by the following personnel:

Bureau of Land Management

William Malencik, Chief, Division of Technical Services, Nevada State Office, Team Leader

Roy Percival, Fire Management Officer, Nevada State Office

Myrvin Noble, Natural Resource Specialist, Denver Service Center

George Weiskircher, Recreation Specialist, Susanville District, California

Paul Cuplin, Fisheries Biologist, Denver Service Center

James Gabetus, Assistant District Manager, Boise District, Idaho

Jack Edwards, Leader, Economics Staff, Denver Service Center

Forest Service

Robert Mutch, Fire Staff Officer, LoLo National Forest, Missoula, Montana

Owen Cramer, Research Meteorologist, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon

Other

Dr. Edwin Komarek, Director, Tall Timbers Research Station, Tallahassee, Florida

Roger R. Robinson (retired BLM), former Director, Boise Interagency Fire Center and State Director, Alaska

Dr. Frank W. Stanton (retired BLM), former Wildlife Specialist, Oregon State Office

Robert Krumm (retired BLM), former Deputy Director, Boise Interagency Fire Center

In addition to those just named, a copy of the working draft was sent to the following for review:

Federal Agencies

Fish and Wildlife Service

Forest Service

National Park Service

Bureau of Land Management: State Offices, Washington Office, Denver Service Center, Boise Interagency Fire Center

The comments received were then circulated among the team preparing the report and considered in the preparation of the draft statement.

During the development of the final draft statement, consulation will continue with the groups and individuals.

COORDINATION IN THE REVIEW OF THE DRAFT ENVIRONMENTAL STATEMENT

Comments on the draft environmental statement will be requested from the following agencies and state clearinghouses:

Advisory Council Historic Preservation

Department of Agriculture
Soil Conservation Service

U.S. Forest Service

Department of Commerce
National Oceanic and Atmospheric Administration
National Fire Prevention and Control Administration

Department of Defense

Environmental Protection Agency

Energy Research and Development Administration

Department of the Interior
Bureau of Indian Affairs
Fish and Wildlife Service
Bureau of Outdoor Recreation
Bureau of Reclamation
Geological Survey
National Park Service

Department of Health, Education, and Welfare
Federal Disaster Assistance Administration

Department of Transportation

National Aeronautics and Space Administration

Water Resource Council

River Basin Commission (Pacific Northwest)

State Clearinghouses
- State of Alaska
- State of Arizona
- State of California
- State of Colorado
- State of North Dakota
- State of South Dakota
- State of Idaho
- State of Montana
- State of Nevada
- State of New Mexico
- State of Oregon
- State of Utah
- State of Washington
- State of Wyoming

PART X

GLOSSARY

air pollution

Air pollution exists when contaminates are present in such quantities and of such duration as may be, or may tend to be, injurious to human, plant, or animal life, or property, or which unreasonably interferes with the comfortable enjoyment of life, or property on the conduct of business.

available fuel

(Separate estimation procedure needed, taking into account total fuel loading, kinds of fuel, condition of fuel, and manner of burning). A very rough approximation of total fuel for oldgrowth, west side fuel: Low-volume slash less than 75 tons/acre; medium-volume slash 75 to 150 tons/acre; high-volume slash over 150 tons/acre. Of this, 75 percent may be removed in a clean broadcast burn (average 50 percent) and 50-90 percent by pile burning, depending on fuels piled and thoroughness of burn.

chunking in

Pushing together the large pieces of fuel in a burning pile or concentration to maintain flaming combustion (instead of smoldering)--speeds the burning process, cleans up the residue, and lessens the chance of holdover fire.

daily quotas

Actual amounts of residue authorized to be consumed by fire--expressed as tonnage of available fuel that is expected to burn and that is less than total fuel. Quota is also expressed in equivalent amount of particulate produced by normal burning of given amount of available fuel, assuming an emission factor of 14 pounds of particulate per ton of forest residue burned. Emission factor varies with fuel and manner of burning.

mixed or unstable layer

Characterized by turbulence and vertical motion, hence permitting convection through the layer and mixing of a plume throughout the layer. Indicated by decrease in temperature with elevation of at least 5 F/1,000 feet.

mixing level or mixed layer

Height or depth to which air heated at the ground during the warm part of the day will normally rise, hence the layer through which emissions from small surfaces sources may be expected to mix. The mixing level is the minimum height to which a substantial smoke convection column from forest or range prescribed burning may be expected to rise.

mop-up

Extinguishing fire including search for and extinguishing of buried and smoldering fire remnants.

no restriction

Limit imposed only by limitations of personnel and equipment to conduct a proper and safe burn and be prepared for mop-up--30,000 tons per district rarely exceeded.

plume dispersal height or smoke venting height

The level in the vicinity of the fire at which the smoke ceases to rise and moves with the wind and turbulence acting at that level. The smoke configuration changes from a convection column to a plume at this height.

residual smoke

Smoke produced after the initial fire has passed through the fuel, usually from smoldering, incomplete combustion, and with insufficient heat or volume to produce appreciable rise.

smoke plume

Smoke from a particular source but not in a well-defined convective column, usually with neutral buoyancy and subject to motions of the air in which it lies. Depending on the fire, it may form at the ground or at the top of a smoke convection column.

smoke plume moving away

Projected plume will not intersect or pass over an SSA boundary within 100 miles downwind from the fire.

smoke plume moving toward

Projected plume will intersect or pass over smoke-sensitive-area boundary within 100 miles downwind from the fire, or plume is within 100 miles of smoke-sensitive-area boundary and wind direction is indeterminate due to wind speed less than 5 mph at plume dispersal height.

smoke-sensitive site

Smaller, special activity areas, such as major recreation sites, in which smoke is particularly objectionable. Here sensitivity to smoke may vary seasonally, by days of the week, with weather conditions, or may exist only for a special occasion.

Changes After Firing. Should conditions deteriorate while burning is in progress, plans for burning should be revised downward to correspond to amounts permissible under the new conditions. Where no burning would be permitted under the revised classification, ongoing burns should be completed quickly and, where practical and safe, fuels chunked in to permit more rapid burning.

Liaison With Air Pollution Control Officials. Regional and State air pollution control agencies must be kept informed of burn plans, operations, and current orders. They receive inquiries about visible smoke plumes and should be kept up to date.

Fire-Weather Forecasts. Each State or district or burning agency will maintain close contact with the fire-weather forecaster of the National Weather Service, to relay weather data pertinent to smoke and fire behavior to the burning agency and to arrange for special weather observations and forecasts as needed.

Precipitating Cloud System. The particulate component of smoke that actually disperses within a precipitating cloud system is likely to become condensation nuclei and be subjected to washout mechanisms that may remove most of it in a short time. A layer of fog or stratus from which drizzle is falling does not qualify.

Optimum Dispersal Winds. Wind speeds of more than 15 mph have been assumed to provide the standard dilution of the smoke plume at venting height. Less burning is permitted in slower winds, which provide less dilution and slower transport of the plume.

Smoke Plumes Aloft. Smoke plumes aloft that are completely separated from surface air by a stable layer do not detract from air quality at the surface and may not be readily distinguishable from normal water droplet clouds or ice crystal clouds. Nevertheless, some limitations are imposed when such clouds are expected to pass over an SSA.

Procedures for Minimizing Smoke Production and Impact

The following are some of the practices which will assist in minimizing the impact of smoke emissions:

Weather. Prior to ignition of the test fire, both the latest fire-weather forecast and the observed conditions at the site must indicate that smoke dispersal as well as fire behavior conditions are favorable. The test fire will help to confirm this.

Time of Ignition. Selection of the correct time to burn will help to minimze the amount, dispersal, and visibility of resulting smoke.

Where burning can be completed in less than 12 hours, ignition should be scheduled, as in the early morning, to take advantage of the heated mixed layer above the surface during the day. Smoke columns normally rise higher, and turbulent dispersion of smoke is more rapid during the warm part of the day. However, morning ignition will not be permitted if fire-danger indices are predicted to rise above safe levels at any time during the burnout period.

If burning requires more than 12 hours, so that considerable smoldering remnants may produce residual smoke following the main burn, ignition at night may minimize drift smoke accumulation. This is effective for heavy fuel, higher elevation burns above the usual valley bottom inversions. The more stable night air is compensated for by the strong convective column phase of the burn. By the time the residual burning stage is reached, daytime heating may be only a short time away so that the low-energy stage of the burn is compensated for by the better daytime dispersion conditons.

Condition of Fuel. Burning of cured or well-dried material is favored as consistent with safety and burning objectives, because it burns hotter, hence will produce less visible emission and will produce a stronger convective column reaching greater heights.

Rapid Firing. The objective is to develop maximum heat energy per unit time in order to vent the smoke at the highest elevation possible. Prescribed burns should be fired as rapidly as safety and the objectives of the burn will permit.

Preparation of Fuel. To achieve maximum flexibility in selection of time of burning and the optimum smoke dispersion conditions, it is often desirable to prepare suitable fuels for burning during the wet season. This may be done by piling or windrowing and covering with plastic to keep the fuel dry through the early fall rains. Fuel piled without soil will burn more efficiently under a much greater variety of weather conditions than fuel requiring broadcast burning. Properly cured, clean piles will also produce less holdover fire and smoldering smoke.

Minimum Particulate. Where the nature of the fire precludes a hot fire, as in light underburning, a backing fire is more efficient and will produce only a fraction of the particulate of a head fire. Without wind, centerfiring will produce a backing fire into the indraft.

allowable burn

The burned acreage, expressed in percentage of are protected that can be tolerated per year in each resource value class.

available nutrient

That portion of any element or compound in the soil that readily can be absorbed and assimilated by growing plants.

biomass

The amount of living matter in a habitat.

biome

One of the largest ecological units of both plants and animals usually identified in terms of the characteristic vegetation.

canopy

The cover of leaves and branches formed by the tops or crowns of plants.

check dam

Small dam constructed in a gully or other small watercourse to decrease the streamflow velocity, minimize channel scour, and promote deposition of sediment.

chieseling

Breaking or loosening the soil, without inversion, with a chisel cultivator or chisel plow.

climate

The sum of all atmospheric or meteorological influences, principally temperature, moisture, wind, pressure, and evaporation, which combine to characterize a region and give it individuality by influencing the nature of its land forms, soils, vegetation, and land use.

climax community

The final stage of a vegetative succession through seral stages to the most stable plant association the site can support.

compaction

To unite firmly; the act or process of becoming compact, usually applied in geology to the changing of loose sediments into hard, firm rock. With respect to construction work with soils, engineering compaction is any process by which the soil grains are rearranged to decrease void space and bring them into closer contact with one another, thereby increasing the weight of solid material per cubic foot.

confierous

Conebearing as a pine tree.

conservation

The protection, improvement, and use of natural resources according to principles that will assure their highest economic or social benefits.

debris

A term applied to the loose material arising from the disintegration of rocks and vegetative material; transportable by streams, ice, or floods.

degradation

To wear down by erosion, especially through stream action.

denitrification

The biochemical reduction of nitrate or nitrite to gaseous nitrogen, either as molecular nitrogen or as an oxide of nitrogen.

deposit

Material left in a new position by a natural transporting agent, such as water, wind, ice, or gravity, or by the activity of man.

deposition

The accumulation of material dropped because of a slackening movement of the transporting agent--water or wind.

desilting area

An area of grass, shrubs, or other vegetation used for inducing deposition of silt and other debris from flowing water, located above a stock tank, pond, field, or other area needing protection from sediment accumulation.

detention dam

A dam constructed for the purpose of temporary storage of streamflow or surface runoff and releasing the stored water at controlled rates.

diversion terrace

Differs from terraces in that they consist of individually designed channels across a hillside, may be used to protect bottomland from hillside runoff or may be needed above a terrace system for protection against runoff from an unterraced area. They may also divert water out of active gullies, protect farm buildings from runoff, reduce the number of waterways, and are sometimes used in connection with stripcropping to shorten the length of slope so that the strips can effectively control erosion. See: terrace.

duff

The more or less firm organic layer on top of mineral soil, consisting of fallen vegetative matter in the process of decomposition, including everything from pure humus below to the litter on the surface. Duff is a general, nonspecific term.

ecosystem

A community of living and non-living components of the environment, where interactions result in an exchange of materials and energy.

endangered species

Those species of plants and animals in danger of extinction throughout all or a significant portion of their range which are officially listed and established by law as endangered.

environment

The surrounding conditions, influences or forces that affect or modify an organism or an ecological community and ultimately determine its form and survival.

erosion

(1) The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep, (2) detachment and movement of soil or rock fragments by water, wind, ice, or gravity. The following terms are used to describe different types of erosion.

accelerated erosion

Erosion much more rapid than normal, natural, or geological erosion, primarily as a result of the influence of the activities of man or in some cases, of other animals or natural catastrophes that expose base surfaces; for example, fires.

geological erosion

The normal or natural erosion caused by geological processes acting over long geologic periods and resulting in the wearing away of mountains, the building of flood plains, coastal plains, etc. Syn. natural erosion.

gully erosion

The erosion process whereby water accumulates in narrow channels and, over short periods, removes the soil from this narrow area to considerable depth, ranging from 1 to 2 feet to as much as 75 to 100 feet.

natural erosion

Wearing away of the earth's surface by water, ice, or other natural agents under natural environmental conditions of climate, vegetation, etc., undisturbed by man. Syn--geological erosion.

normal erosion

The gradual erosion of land used by man that does not greatly exceed natural erosion. See: natural erosion.

rill erosion

An erosion process in which numerous small channels only several inches deep are formed; occurs mainly on recently cultivated soils.

sheet erosion

The removal of a fairly uniform layer of soil from the land surface by runoff water.

soil erosion

The detachment and movement of soil from the land surface by wind or water.

splash erosion

The spattering of small particles caused by the impact of raindrops on wet soils. The loosened and spattered particles may or may not be subsequently removed by surface runoff.

surface erosion

The detachment and transport of individual soil particles by water, wind, or gravity.

wind erosion

The detachment and transportation of soil by wind.

eutrophication

The excessive accumulation and retention of nutrients by aquatic ecosystem from man-made or natural causes, often resulting in oxygen deficiency.

fertilizer

Any organic or inorganic material of natural or synthetic origin that is added to a soil to supply elements essential to plant growth.

fire climax

A plant association, forest type, or cover type held at a seral stage by periodic fires.

fire management

The control or use of fire to protect human life and property and to enhance the productive capability of public lands--to meet resource production and other human needs.

fire mosaic

A seral plant stage established and maintained naturally through cyclic recurrence of fire.

grazing system

A systematic sequence of grazing use and nonuse of an allotment to reach identified multiple-use goals or objectives by improving the quality of vegetation.

hazard (fire hazard)

A fuel complex forming a special threat of ignition or of suppression difficulty.

hazard reduction

Any treatment of slash, litter, snags, and other material that reduces threat of ignition, spread, and resistance to control of a fire.

herbicide

A chemical substance used for killing plants, especially weeds.

hour control

The estimated elapsed time between the origin of the fire and the arrival of the first suppression force.

humus

That more or less stable fraction of the soil organic matter remaining after the major portion of added plant and animal residues have decomposed; usually amorphous and dark colored.

impoundment

Generally an artificial collection or storage of water, as a reservoir, pit, dugout, sump, etc. See: reservoir.

infiltration

The flow of a liquid into a substance through pores or other openings, connoting flow into a soil in contradistinction to the word "percolation" which connotes flow through a porous substance.

infiltration rate

A soil characteristic determining or describing the maximum rate at which water can enter the soil under specified conditions, including the presence of an excess of water.

leaching

The removal of materials in solution from the soil.

lightning fire

A fire that is ignited by lightning.

man-caused fire

A fire that is ignited or caused by a human.

management action

A supervisory decision affecting the manner and method of use of the resources of a land area.

management framework plan (MFP)

Land use plan for public lands which provides a set of goals, objectives, and constraints for a specific planning area to guide the development of detailed plans for the management of each resource.

mass soil erosion (landslides)

The detachment and downslope movement of relatively large quantities of soil at one time occurring primarily during wet soil conditions with gravity as the moving force.

mechanical practices

Soil and water conservation practices that primarily change the surface of the land or that store, convey, regulate, or dispose of runoff water without excessive erosion.

microclimate

The climate of a very small site or habitat.

mulch

A natural or artificial layer of plant residue or other materials, such as sand or paper, on the soil surface.

multidisciplanary team

A group of persons who collectively have expertise on all aspects of components of a project or problem to be studied and/or solved.

multiple use

Harmonious and coordinated management of the various surface and subsurface resources which will best meet the present and future needs of the people, without impairment of the land.

natural fire

A fire ignited by natural causes such as lightning and spontaneous combustion.

nitrification

The biological oxidation of ammonium salts to nitrites and the further oxidation of nitrites to nitrates.

nonwettable soil

A condition of the soil which may occur after wildfire where the soil loses its affinity for water.

normal fire year

The year with the third greatest number of forest fires in the past ten.

normal fire year plan (NFYP)

A fire activity plan designing the organization and facilities needed to meet protection standards of a management unit in a normal fire year.

off-road vehicle (ORV)

Any motorized vehicle designed for or capable of cross-country travel on or immediately overland, water, sand, snow, ice, marsh, swampland, or other terrain.

overgrazing

Consumption of vegetation by herbivores beyond the endurance of a plant to survive.

parent material

The unconsolidated and more-or-less chemically weathered mineral or organic matter from which soil develops.

pasture

As used in this document, a pasture is a subdivision of a grazing allotment is divided into three pastures.

pathogen

A specific cause of disease, as a bacterium or virus.

pesticide

A chemical agent used to control pests.

planning unit

A geographic subdivision of a BLM district for planning and management purposes. There are approximately 500 planning units on 60 districts.

plant vigor

The relative well-being and health of a plant as reflected by its ability to manufacture sufficient food for growth and maintenance.

pollution

Any change in the character of air and water adversely affecting its usefulness.

postsuppression

The activity directed towards the rehabilitation of fire-related damages.

prescribed burning (prescribed fire)

Controlled application of fire to wildland fuels in either their natural or modified state, under such conditions of weather, fuel moisture, etc., as to allow the fire to be confined to a predetermined area while producing the intensity of heat and rate of spread required to achieve certain planned objectives of silviculture, wildlife management, grazing, fire hazard reduction, and insect and disease control.

presuppression and prevention

The activity in advance of fire occurrence to ensure effective fire suppression and the organized effort to reduce the number and size of wildfires.

programmatic statement

A comprehensive and general statement resulting from an analysis of the adverse and beneficial impacts on the environment as it is being affected by an ongoing management program.

public land

Any land and interest in land owned by the United States within several states and administered by the Secretary of the Interior through the Bureau of Land Management.

public participation

A component of the Bureau Planning System providing the opportunity for citizens as individuals or groups to review resource management proposals and offer their suggestions or criticisms of the various alternatives offered.

rainfall intensity

The rate at which rain is falling at any given instant, usually expressed in inches per hour.

reservoir

Impounded body of water or controlled lake in which water is collected or stored.

resource value class

One of five relative value classes (class V being the highest) into which all lands and resources in each planning unit have been inventoried and classified. Classification considers soil, water, location, timber, grazing, recreation, wildlife, and air space.

risk (fire risk)

The chance of a fire starting as determined by the presence and activity of causative agents.

rotation grazing system

A grazing system providing for sequential movement of livestock from one pasture to another on the basis of allowing for regrowth of vegetation and maintenance of vegetative vigor.

runoff (hydraulics)

That portion of the precipitation on a drainage area that is discharged from the area in stream channels. Types include surface runoff, groundwater runoff, or seepage.

sediment

Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice and has come to rest on the earth's surface either above or below sea level.

sediment discharge

The quantity of sediment, measured in dry weight or by volume, transported through a stream cross-section in a given time. Sediment discharge consists of both suspended load and bedload.

seral

Relating to a successional stage in a plant community.

sheet flow

Water, usually storm runoff, flowing in a thin layer over the ground surface. Syn--overland flow.

slope

Degree of deviation of a surface from the horizontal, usually expressed in percent or degrees.

soil despersion

The breaking down of soil aggregates into individual particles, resulting in single-grain structure. Ease of dispersion is an important factor influencing the erodibility of soils. Generally speaking, the more easily dispersed the soil, the more erodidble it is.

soil fertility

The quality of a soil that enables it to provide nutrients in adequate amounts and in proper balance for the growth of specified plants when other growth factors, such as light, moisture, temperature, and the physical condition of the soil, are favorable.

soil organic matter

The organic fraction of the soil that includes plant and animal residues at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by the soil population. Commonly determined as the amount of organic material contained in a soil sample passed through a 2-millimeter sieve.

soil structure

The combination or arrangement of primary soil particles into secondary particles, units, or peds. The secondary units are characterized and classified on the basis of size, shape, and degree of distinctness into classes, types, and grades, respectively.

soil texture

The relative proportions of the various soil separates in a soil. The textural classes may be modified by the addition of suitable additives when course fragments are present in substantial amounts; for example, gravelly silt loam. Sand, loamy sand, and sandy loam are further subdivided on the basis of the proportions of the various sand separates present.

subclimax

The seral stage in plant succession preceding climax.

subsoiling (ripping)

The tillage of subsurface soil, without inversion, for the purpose of breaking up dense layers that restrict water movement and root penetration.

suppression

The activity beginning with discovery of a wildfire, continuing until it is extinguished.

terrace

An embankment or combination of an embankment and channel constructed across a slope to control erosion by diverting or storing surface runoff instead of permitting it to flow uninterrupted down the slope. Terraces or terrace systems may be classified by their alinement, gradient, outlet, and cross-section. Alinement is parallel or nonparallel. Gradient may be level, uniformly graded, or variably graded. Grade is often incorporated to permit paralleling the terraces. Outlets may be soil infiltration only, vegetated waterways, tile outlets, or combinations of these. Cross-sections may be narrow base, broad base, bench, steep backslope, flat channel, or channel.

threatened species

Those species of wildlife that are likely to become endangered within the forseeable future throughout all or a significant portion of their range, and are officially listed as such by law.

tillage

The operation of implements through the soil to prepare seedbeds and root beds.

values-at-risk (values at stake)

The values that may be adversely affected by fire.

vegetative cover

All plants of all sizes and species found on an area, irrespective of whether they have forage or other value. Syn--plant cover.

water control (soil and water conservation)

The physical control of water by such measures as conservation practices on the land, channel improvements, and installation of structures for water retardation and sediment detention (does not refer to legal control or water rights as defined).

weed

A plant out of place.

wildfires (wildland fires)

Any fire not prescribed by an authorized plan.

ABBREVIATIONS

ANCSA	Alaska Native Claims Settlement Act
AUM	animal unit month
AWC	available water capacity
BIFC	Boise Interagency Fire Center
BLM	Bureau of Land Management
CEQ	Council on Environmental Quality
EFF	emergency firefighters
EIS	environmental impact statement
FCC	fire control condition
HG	hydrologic group
I&E	information and education
MFP	Management Framework Plan
NFYP	Normal Fire Year Plan
UC	unified classification
URA	Unit Resource Analysis

APPENDIX

TABLE K-1.

Some Characteristics, Uses, Limitations of Dominant Soils Occurring in the Northern Temperate Grassland

Soil Name	Location	Unified Classification	Available water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
WILLIAMS	Montana Dawson Co.	CL	12	B	1-8	Crops	Cropland
Limitations-Slight to moderate erosion hazard.							
CHERY	Montana Dawson Co.	CL	10-14	C	0-25	Crops grasses	Cropland rangeland
Limitations- Slight to moderate erosion hazard; poor roadfill material.							

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
FARGO	Montana Judith Basin Area	CH	--	D	0-3	Sedges & rushes	Pasture
Limitations- Poorly chained; calcareous clays; high water table; severe compaction hazard; slight erosion hazard; soil management is very difficult.							
Slickspots	Colorado Sedwick Co.	ML	2-4	B	0-5	Winter grains	Dryland farming
Limitations - Pan of about 15 inches exists; severe erosion hazard.							
Dune Lana	Colorado Morgan Co.	SP	3-6	A	5-25	Sparse grass	Limited grazing
Limitations - Dunes are actively blowing; very severe wind erosion hazard.							

TABLE K-1-2

Soil Name	Location	Unified Classification	Available water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
BAINVILLE	N. Dakota Sterrk Co.	CL	2	C	3-40	Crops & grass	Cropland rangeland
Limitations - Severe wind and water erosion hazard; over clayey shale; low natural fertility.							
Crete #1 a	Nebraska	CH	9-12	-	0-5	Row crops, hay & pasture, short & reed grasses	Range, farming
Limitations - Moderate erosion hazard; high in fertility; high shrink-swell potential.							
TILLMAN #2 b	Texas	CL, CH	9-12	-	1-3	Short grasses, small grains	Range, cultivated crops

TABLE K-1-3

Soil Name	Location	Unified Classification	Available water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
Limitations - High natural fertility; droughty; slight erosion hazard.							
BADLAND #3 b	Texas	--	--	D	2-12 to 20-75	Some short grasses	--
Limitations - This land supports little vegetation; it is thoroughly dissected by large gullies and by bald ridges and knobs; high erosion hazard.							
PORT #3 c	Oklahoma	ML, CL	6-9	C	nearly level	Small grains, hay orchards, pasture	Farming
Limitations - Flood plain; calcareous substratum; thick surface layers.							
RICHFIELD #4 d	Kansas	CL, CH	9-12	C	3	Small grains, mature grasses	Dry farming, range
Limitations - Table land; well drained; susceptible to wind and water erosion; natural ferility is high.							

TABLE K-1-4

Soil Name	Location	Unified Classification	Available water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use

#1 a U.S. Department of Agriculture, Soil Conservation Service, 1964 Soil Survey, Gage County, Nebraska, 76 pp., illustrated.

#2 b U.S. Department of Agriculture, Soil Conservation Service, 1964 Soil Survey, Foard County, Texas, 71 pp., illustrated.

#3 c U.S. Department of Agriculture, Soil Conservation Service, 1967 Soil Survey, Comanche County Oklahoma, 58 pp., illustrated.

#4 d U.S. Department of Agriculture, Soil Conservation Service, 1965 Soil Survey, Wichita County, Kansas, 63 pp., illustrated.

TABLE K-1-5

Table K-2.--Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the Southern Temperate Grassland

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
REEVES #2	Texas	CL	3-6	C	0-20	Desert shrub, salt tolerant grasses	Range
Limitations - Salinity; high corrosion potential; calcareous outwash; gypsum in the subsoil.							
BREWSTER #3	Texas	Gc, GM	0-3	D	6-60	Short grasses, mid grasses, desert shrubs	Range wildlife, recreation
Limitations - Bedrock within 20 inches; stony.							
GOLIAD #3	Texas	CL	3-6	C	0-12	Short & mid grasses	Range, crops, wildlife
Limitations - High shrink-swell potential; severe building							

Table K-2.--Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the Southern Temperate Grassland--Continued

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
		foundations problems; high corrosion potential; shallow to moderate depths over the caliche.					
ECT- or #2	Texas	CL	0-3	D	0-3	Short & mid grasses	Range crops, wild-life, recreation

Limitations - Bedrock or cemented caliche within 20-inch depth; stoniness; moderate shrink-swell potential; high erosion hazard.

#1 Department of Agriculture, Communications, Texas A&M University, General soil map of Texas.

#2 U.S. Department of Agriculture, Soil Conservation Service, 1969, Soil Survey, Howard County, Texas, 68 pp., illustrated.

#3 U.S. Department of Agriculture, Soil Conservation Service, Unpublished soil descriptions.

Prairie Grassland

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
CONDON	Oregon	CL	3-6	C	0-35	bb Wheat, I fescue	Range, dry farmland
Limitations - Wind erosion hazard is medium to high.							
WALLA #1	Oregon	CL	6-9	B	0-35	bb Wheat, I fescue	Range, dry farm land
Limitations - Wind erosion hazard is medium to high.							
WUNTHERN #1	Oregon	SM, ML	6-9	C	35-70	Idaho fescue	Range
Limitations - Somewhat excessively drained; stony or rock north facing-soil; erosion hazard is severe; fertility is moderate.							
LICKSKILLET #1	Oregon	CL	2-5	D	7-70	bb wheat	Range

Limitations - Very to extremely stony, south-facing uplands; natural fertility is low.

Table K-3.--Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the Palouse Prairie Grassland--Continued

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
QUINCY #2	Washington	SP	0-3	A	0-30	Sagebrush, grassland	Range

Limitations - Excessively drained soils in dunes; severe wind erosion hazard.

#1 U. S. Department of Agriculture, Soil Conservation Service, 1964, Soil Survey, Sherman County, Oregon, pp. 104, illustrated.

#2 U.S. Department of Agriculture, Soil Conservation Service, 1971. Soil Survey, Benton County, Washington, pp. 72.

Table K-4.--Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the California Prairie Grassland

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
MERCED	California	CH, ML	12+	C/D	0-3	Crop plants, annual grasses	Row crops
Limitations - Fine-textured alluvium; most has been made land; alkaline and saline; pumping is done to remove water from the soil.							
FRESNO	California	ML, SM	9-12	B	0-3	Vegetable crops, etc.	Cultivated, irrigated
Limitations - Sandy alluvium; water table, 30-75 feet.							
POSITAS	California	CH	1-4	D	0-3	Annual grasses and forbs	Pasture or range
Limitations - Gravelly, cobbly alluvium; water supplies are short; high erosion hazard.							
VISTA	California	SM	1-4	C	3-70	Annual grasses	Range

Table K-4.--Some characteristics, Uses, and Limitations of Dominant Soils Occuring in the California Prarie Grassland--Continued

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
Limitations - Shallow to moderately deep upland soils; water supply is limited; high erosion hazard.							
CIBO	California	CH	5-8	D	3-70	Annual grasses and forbs	Range
Limitations - Clayey soils over igneous rock outcrops are common; water sources are limited.							
AUBERRY	California	SC	5-8	D	3-70	Trees, grasses, and shrubs	Range, dry farmed, grain
Limitations - Moderately coarse-textured soils on upper foothills; rock outcrops are common; erosion is moderate to severe.							

Source: U.S. Department of Agriculture, Soil Conservation Service, 1971. Soil Survey, Eastern Fresno Area, California, pp. 323.

Table K-5.--Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the Hot Desert

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
ANTHONY #1	Arizona	SM	9-12	-	0-5	Annual grasses, shrubs and cacti	Range, irrigated crops, urban development
Limitations - Alkaline and calcareous throughout; moderately rapid permeability.							
MOHAVE #1	Arizona	CL	9-11	-	0-3	Annual grasses, desert shrubs	Desert range, irrigated crops, urban development, wildlife
Limitations - Calcareous throughout.							
CAIRE #2	Arizona	SM	0-3	-	0-30	Annual grasses, desert shrubs	Range, wildlife
Limitations - Calcareous, gravelly over a hardpan; natural fertility is low.							

TABLE K-5.--Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the Hot Desert--Continued

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
CIONEHA #3	California	SM, GM	0-3	C	5-30	Annual grasses, small grains	Range, dryland farming, pasture, homesites
Limitations - Somewhat excessively drained upland soils; high erosion hazard; rapid permeability.							
CHINO #3	California	CL	9-11	B-C	0-2	Annual grasses, weeds, small grains, grasses and legumes	Hay, pasture, dryland grain, homesites
Limitations - Somewhat poorly drained to poorly drained floodplains; saline-alkaline soils, slight erosion hazard; can be drained to improve salt content.							
ROCKLAND	California	--	0-3	C	15-75	Annual grasses	Wildlife
Limitations - Granite boulders and rock outcrops that cover 35 to 60 percent or more of the surface; high erosion hazard.							

#1 U.S. Department of Agriculture, Soil Conservation Service, 1972. Soil Survey, Tucson-Avra Valley Area, Arizona, pp. 70, illustrated.

TABLE K-5.--Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the Hot Desert--Continued

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use

#2 U.S. Department of Agriculture, Soil Conservation Service, 1970. Soil Survey, Safford Area, Arizona, pp. 56, illustrated.

#3 U.S. Department of Agriculture, Soil Conservation Service, 1971. Soil Survey, Western Riverside Area, California, pp. 159, illustrated.

Table K-6.--Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the Cold Desert

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
BILLINGS	Utah	ML	6-10	C	0-10	Range, irrigated crops and grasses	Range, cropland
Limitations -							
KENILWORTH	Utah	SM	3-5	B	0-20	Juniper-pinon	Range
Limitations - Shallow; droughty; calcareous; reseeding hazard; moderate erosion hazard, stoney soil.							
JEKLEY	New Mexico	CL	2-6	C	3-40	Pine-grass	Forest, Range
Limitations - Moderate to severe erosion hazard; shallow soil; cold soil temperatures; high fertility.							
HUMBOLT #1	Nevada	MH	9-12	D	0-3	Salt tolerant shrubs and grasses, irrigated crops	Irrigated crops

Table K-6.--Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the Cold Desert

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
Limitations - Imperfectly drained along streams and shallow lakes; saline and alkaline; slight erosion hazard.							
QUINCY #1	Nevada	SP	0-3	A	3-12	Greasewood, rabbit brush, Indian grass	Range, some vegetation
Limitations - Excessively drained; wind blows verticals; rapid infiltration; natural fertility very low; severe erosion hazard; wind and water.							
PLACERITOS # 1	Nevada	ML	9-12	C	0-3	Greasewood saltbrush	Range, irrigated crops
Limitations - Imperfectly drained in alluvium; saline-alkaline sacts; water table, 4-6 feet; slight erosion hazard.							
VOLTAIRE #2	Nevada	CH, MH	9-12	D	0-3	Saltgrass, sedges, fescue	Pasture, hay, grains
Limitations - Poorly drained in clay alluvium; fluctuating water table, 20-36 inches; natural fertility is high.							

Table K-6.--Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the Cold Desert

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
MOTTSVILLE #1	Nevada	SW,	3-6	A	3-45	Big sage, bitterbrush	Grazing
Limitations - Excessively drained, alluvial faces; erosion hazard slight to moderate; susceptible to wind erosion; natural fertility is low.							
BAKEOVEN #3	Idaho	ML, CL	0-3	D	0-80	Big sage, sandberg bluegrass	Grazing
Limitations - Very shallow sacts on basalt; erosion hazard severe on steeper slopes, very strong throughout.							
GEM #4	Idaho	CH, MH	6-9	C	0-60	Big sage, bb wheat	Dryfarmed, irrigated, range
Limitations - CaCo3 below 15 feet; slight to severe erosion hazard.							
DESCHUTES #1	Oregon	SM	3-6	C	0-20	Juniper, grassland	Range, irrigation, homesites

Table K-6.--Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the Cold Desert--Continued

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
Limitations - Somewhat excessively drained, high terraces; wind erosion is high, natural fertility is low.							
DAY #4	Oregon	CH	3-6	D	6-40	Big sage, bb wheat	Range
Limitations - High shrink-swell; cracks when dry; high water erosion hazard.							
SALISBURY #4	Oregon	CL	3-6	D	0-20	Big sage, Idaho fescue, bb wheat	Range, dry farmed, small grains
Limitations - Well-drained soils with silic-cemented pan; stony soils.							

#1 U.S. Department of Agriculture, Soil Conservation Service, 1965. Soil Survey, Lovelock Area, Nevada, pp. 87, illustrated.

#2 U.S. Department of Agriculture, Soil Conservation Service, 1971. Soil Survey, Carson Valley Area, Nevada, pp. 129, illustrated.

#3 U.S. Department of Agriculture, Soil Conservation Service, 1965. Soil Survey, Gem County, Idaho, pp. 188, illustrated.

Table K-6.--Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the Cold Desert--Continued

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
#4 U.S. Department of Agriculture, Soil Conservation Service, 1966. Soil Survey Prineville Area, Oregon, pp. 89, illustrated.							

Table K-7.--Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the Woodland-Bushland Biome

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
ARNOLD #1	California	SP, SM	3-5	A	9-50	Annual grasses, and shrubs	Range
Limitations - Somewhat excessively drained sandy soils over soft sandstone; erosion hazard is moderate to severe; low fertility.							
CAMARILLO #1	California	SM	7-9	C	0-2	Salt tolerant grasses and shrubs	Vegetables, lemons, homesites
Limitations - Poorly drained sandy soils; where not drained, water table is at 2 feet; subject to flooding; high fertility.							
DIABLO #1	California	CL	6-9	D	9-50	Annual grasses and oak	Range
Limitations - Well-drained clays in shale uplands; erosion hazard moderate to severe; high shrink-swell potential.							

Table K-7.--Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the Woodland-Bushland Biome--Continued

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
GAVIOTA #1	California	SM	0.5-1	D	15-50	Annual grasses,	Range
Limitations - Shallow well-drained sandy soils over sandstone; erosion hazard is moderate to severe, inherent fertility is low.							
GAZOS #1	California	GM	3-6	C	15-75	Brush and annual grasses	Range and homesites
Limitations - Silty soils over fractured shale; erosion hazard is severe; natural fertility is high.							
LOS OSOS #1	California	CL	4-8	C	9-50	Annual grasses, forbs, birch, oak	Range, citrus field crops, homesites
Limitations - Clayey soils over shale; erosion hazard is severe; natural fertility is high.							

Table K-7.--Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the Woodland-Bushland Biome--Continued

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
Limitations - Clayey soils on plains; no erosion hazard, high in fertility.							
LAS POSAS	California	CH	4-6	C	2-65	Chaparral-oak, annual grasses	Field crops, row crops, orchards, range
Limitations - Sandy soils from basic igneous rocks; fertility is medium; erosion hazard is high to very high.							
BOOMER #2	California	CL	7-10	B	15-75	Conifer forest, deciduous	Wood products
Limitations - Loams over metamorphosed uplands; erosion hazard is very high; fertility is moderate.							

#1 U.S. Department of Agriculture, Soil Conservation Service, 1970. Soil Survey, Ventura Area, California, pp. 148, illustrated.

#2 U.S. Department of Agriculture, Soil Conservation Service. Soil Survey, San Diego Area, California, draft manuscript, Portland, Oregon.

Table K-8.--Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the Montane Coniferous Forest--Continued

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
Limitations - Shallow foothills; moderate fertility; erosion hazard is moderate to very severe.							
WOODSIDE #3	Montana	SM, ML	3-6	A	5-35	Conifer forest	Wood products
Limitations - Somewhat excessively drained footslopes and terminal moraines; low natural fertility; erosion hazard is high.							
SLOCUM #3	Montana	ML	9-12	B	0-3	Deciduous forest and grasses	Pasture, hay, small grains
Limitations - Imperfectly to moderately well-drained fans and terraces; most areas are subirrigated; imperfectly drained ares are saline.							
STEEUM #4	Colorado	ML	0-3	D	0-70	Pinon-juniper, grasses	Range, watershed
Limitations - Erosion hazard is very high; rock outcrops are common; 20 to 40 percent gravel content; moderately low fertility; droughty soils.							
BROLLIAS #5	Arizona	CH	6-9	-	0-30	Pine-grass	Wood products, summer range

Table K-8.--Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the Montane Coniferous Forest--K Continued

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
Limitations - Hilly upland; 20 to 60 percent surface stones and cobbles; low erosion hazard.							
SPUNGLE-VILLA #5	Arizona	CH	6-9	D	0-20	Pine-juniper	Range
Limitations - High shrink-swell potential cracks when dry; 30 to 50 percent surface stones; erosion hazard is moderate.							
ROCK-SLIDES #5	Colorado	GP	--	A	10-100	Spruce, alpine fields, mostly barren	Recreation
Limitations - Accumulations of loam rocks from landslides; some slides are stable; some slides near faces of cliffs are unstable; no erosion hazard; springs are common at the top slope.							

#1 U.S. Department of Agriculture, Soil Conservation Service, 1971. Soil Survey, Kooskia Area, Idaho, pp. 96, illustrated.

#2 U.S. Department of Agriculture, Soil Conservation Service, 1965. Soil Survey Amador Area, California, pp. 160, illustrated.

#3 U.S. Department of Agriculture, Soil Conservation Service, 1959. Soil Survey, Bitterroot Valley Area, Montana, pp. 128, illustrated.

Table K-8.--Some Characteristics, Uses, and Limitations of Dominant Soils

Occurring in the Montane Coniferous Forest--Continued

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use

#4 U.S. Department of Agriculture, Soil Conservation Service, 1961. Soil Survey, Trout Creek Watershed, Colorado, pp. 48, illustrated.

#5 U.S. Department of Agriculture, Soil Conservation Service, 1967. Soil Survey, Beaver Creek Area, Arizona, pp. 75, illustrated.

#6 U.S. Department of Agriculture, Soil Conservation Service, 1962. Soil Survey Fraser Alpine Area, Colorado, pp. 47, illustrated.

Table K-9.--Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the Northwest Coastal Forest

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
HUGO #1	California	SC	4-8	B	6-60	Conifer forests, shrubs, grasses forbs	Forestry
Limitations - Very gravelly soils; very high erosion hazard.							
CLEAR LAKE #2	California	CH	8-10	D	0-3	Grasses, shrubs, forbs	Hay, grain, orchards
Limitations - Shrink-swell potential is high; 3-5 feet to seasonal water table; surface cracks when dry; runoff is slow until surface is sealed, then it is rapid; drainage improved productivity.							
YOLO #1	California	ML	9-12	B	0-3	Annual and perennial crops	Cultivated crops, orchards
Limitations - Subject to flooding; well drained.							
ORFORD #2	Oregon	MH	9-12	C	3-60	Conifer forest	Woodcrops

Table K-9.--Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the Northwest Coastal Coniferous Forest--Continued

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
Limitations - Severe							
ACTIVE DUNE-LAND #2	Oregon	SP, SM	--	-	3-40	None	Recreation
Limitations - Unstable and subject to severe soil blowing; droughty; vegetation is difficult to establish.							
HEMBRE #3	Oregon	ML	9-12	B	12-60	Conifer forest	Wood products
Limitations - High erosion hazard in cut banks; highly productive; stable mantles.							
NAHALEM #3	Oregon	ML, CL	12	B	3-12	Grass, legumes	Pasture
Limitations - Alluvial bottoms; subject to flooding.							
AMITY] #4	Oregon	ML, CL	9-12	C	0-3	Annual and perennial grasses	Pasture, grains, & seeds
Limitations - Somewhat poorly drained terraces; compaction potential is high; water table.							

Table K-9.--Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the Northwest Coastal Coniferous Forest--Continued

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use
KINNEY] #4	Oregon	ML	5-9	B	3-60	Conifer forest	Wood products
Limitations - Well-drained uplands; unstable on steep slopes; erosion hazard high on steep slopes; subject to frost heaving.							
CINEBAR #5	Washington	SM	6-9	B	0-3	Row crops, hay pasture, orchards	Farming
Limitations -							
GROVE- #6	Washington	GP,	3-6	A	3-60	Conifer forest	Wood products, feed crops, homesites
Limitations - Glacial outwash plains; gravelly soils; soils are droughty and low in fertility.							

#1 U.S. Department of Agriculture, Soil Conservation Service, 1972. Soil Survey, Sonoma County, California, pp. 188, illustrated.

Table K-9.--Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the Northwest Coastal Coniferous Forest--Continued

Soil Name	Location	Unified Classification	Available Water capacity (inches)	Hydrologic group	Relief (%)	Vegetation	Major Use

#2 U.S. Department of Agriculture, Soil Conservation Service, 1970. Soil Survey, Curry Area, Oregon, pp. 69, illustrated.

#3 U.S. Department of Agriculture, Soil Conservation Service, 1969. Soil Survey, Tillimook Area, Oregon, pp. 75, illustrated.

#4 U.S. Department of Agriculture, Soil Conservation Service, 1972. Soil Survey Marion County, Oregon, pp. 132, illustrated.

#5 U.S. Department of Agriculture, Soil Conservation Service, 1972. Soil Survey, Clark County, Washington, pp. 113, illustrated.

#6 U.S. Department of Agriculture, Soil Conservation Service, 1960. Soil Survey, Mason County, Washington, pp. 76, illustrated.

APPENDIX B

Classification of Hazard-Reduction Practices

As part of the presuppression and prevention activity, a hazard-reduction practice may be classified according to its intended purpose, or as follows:

- Removal of all ignitable fuel in limited areas of special risk. The cleared and burned railway right-of-way is an example, as is the zone kept clear of fuels around sawmill burners, city dumps, etc. It is represented on a more extensive scale where forest or grass areas are burned over under control to avoid subsequent ignition from known sources of risk. The common purpose is the automatic prevention of ignitions by removal of fuels.

- Removal of all fuels in a strip close to or around the source of risk in order to confine any fire to a small isolated area. This kind of measure frequently substitutes for complete removal in cases cited above. Cleanup of fuels or exposure of soil in a strip along roadsides to create firebreaks to confine roadside fires is a familiar example. The purpose is both prevention of ignitions and containment.

- Removal of fuel in a strip where the purpose is to exclude fire from a high-value or high-hazard area. Firebreaks around a forest plantation are a typical example.

- Removal of fuels to reinforce natural breaks and to create new ones by which an area can be broken up into blocks to facilitate control of wildfires. This is a familiar pattern in California brushlands.

- Use of prescribed burning, when coarse and intermediate fuels are moist, to safely remove flash fuels from considerable areas. Similar use on smaller areas to strongly reduce fuel hazards. The purpose is to reduce the energy output and the rate of spread of wildfires so they will be much easier to control and will do less damage.

- Removal of dead snags or trees that would throw spot fires if ignited. This is a familiar requirement in timber sale areas. The purpose is assurance to the firefighter that his efforts will not be frustrated by a succession of spot fires from embers flying overhead.1/

The application of hazard-reduction measures to serve these purposes requires decisions based on careful evaluation and planning, including air pollution considerations. The fire problem is directly proportional to the relationship between hazard and risk. Preventive action will be necessary on areas having high hazard which are exposed to fire risks. All BLM-administered lands are analyzed for hazard-risk relationships to determine the magnitude of the fire problem.

1/ A.A. Brown and K.P. Davis, 1973. Forest Fire Control and Use. McGraw-Hill, New York

APPENDIX C

Detection

Detection is a key element of fire management. Before anything can be done toward controlling a fire, its existence must be known. Smoke is normally the telltale evidence upon which detection is based.

Detection of fire is ordinarily accomplished by one or more of the following conventional methods and facilities:

- By lookouts planned, designed and implemented for the purpose-- Nearly all agencies use lookouts, though they vary in the degree of dependence thereon. The number of lookouts in the United States reached peak numbers of about 5,000 in 1953, but currently number about 3,000. Further reductions will occur because changing conditions make other methods of detection, such as aerial patrol, more effective and economical.

- By aerial patrol over predetermined routes at specific intervals-- The use of aircraft to detect fires today is nearly universal among fire management agencies. This practice is heavily used to pick up any undiscovered lightning fires after significant lightning storms.

- By ground patrol over predetermined routes at specific times-- The ground detection patrol is generally used within the more dangerous risk areas and/or high-risk periods.

- By planned arrangements with cooperators and local residents-- Resident cooperators have augmented other detection methods. It's an economical method and the probability of such discoveries increase with the number of visitors. Airline companies have been particularly effective in detecting and reporting fires.

- By automatic lightning detection system (ALDS) field units located at 250 mile intervals. This new sensing system accurately detects cloud to ground lightning strikes within +/- one mile of the ground strike.

APPENDIX D

Fuelbreak and Slash Disposal Considerations

Fuelbreaks

Fuels can be modified selectively by building fuelbreaks at strategic locations where protection priorities have been determined. Good locations for fuelbreaks are: (1) Prominent ridges that separate major drainages; (2) bottoms of wide drainages; (3) roads and highways; (4) the base of mountains; and, (5) boundaries of communities, camps, or special management areas.

Timber sales can be used to establish fuelbreaks in commercial timber areas. The main objective in planning and laying out fuelbreaks is protecting resource values and environmental quality. The completed fuelbreak should maintain or even enhance the natural beauty of the area. In planning a fuelbreak program, use the expertise provided by landscape architects and other specialists, whenever possible.

In timber, plan park-like, shaded fuelbreaks. Completely cleared strips are to be used only in open brush and will require careful landscaping. Timbered fuelbreaks should be selectively logged to separate tree crowns, yet allow continuous production of timber which may even increase in quality and quantity.

After logging and before slash cleanup, consider pruning leaf trees to eliminate "ladder" fuels near the ground. Opening the timber canopy and removing fuels should reduce crown fire potential, and provide ground conditions that permit firefighters to control a fire's spread more easily and safely.

When deciding whether to build fuelbreaks, consider land values as well as impacts on other resources. Will fuelbreak installation and maintenance buy more long-term protection than the land now had, and will have as a result of projected resource activities?

Slash Disposal

Fire hazard increases greatly in timbered areas following cutting primarily because of the increase in the amount of the finer and potentially flammable fuels from the tree crowns and limbs. The degree of hazard is affected by the following conditions:

The quantity of slash created--This is affected by the volume cut by species, the method of logging, and the care exercised during logging.

Much slash results from road construction and damage to residual trees in addition to the slash from harvested trees.

The distribution of slash, that is, whether slash is patchy or more or less continuous--This is a function of the character of the timber stand and the method of logging. With tractor skidding, for example, much of the slash is windrowed along skid trails.

The flammability of slash--There are substantial differences between deciduous and coniferous species as well as within these groups. There are substantial differences too due to arrangement of the slash. If slash is lopped or flattened to place it in close contact to the ground, moisture contents remain higher and kindling fuels are less effective.

The duration of hazard--This is controlled by the volume of the slash created and by the rate of disintegration. Tree species and environments differ markedly in this respect.

Degree of wood utilization--The availability and feasibility of wood products markets strongly influence the amount, kinds, and sizes of slash left after cutting. Diameter size of slash has a direct relationship to flammability.

Microclimatic changes resulting from more open stand conditions following cutting--These include higher surface temperatures and increased air movement near the ground, which accelerate both drying of fuels and rate of spread should a fire start. Marked changes surface vegetation also follow logging. Together, such changes may exert a larger total effect on hazard than the slash itself.

The size of the area cut--In general, the larger the area, the greater the total hazard.

The frequency and pattern of logging roads or skid trails that may serve as firebreaks and that improve accessibility--Roads may, however, increase risk since they permit more hunters, berry pickers, fishermen, and others to enter the area.

There are two general methods of slash disposal that require use of fire: (1) pile (or bunch) and burn and (2) broadcast burn. They may be applied singly or sometimes in combination in treating an area. Lop and scatter and clipping of slash are also employed, but do not require fire.

The essential feature of pile-and-burn methods is that logging slash and other debris are assembled in separate piles and burned. Substantial hazard reduction results from piling alone in some situations. The most frequent practice is to pre-pile and then burn during some safe period, usually late fall or early winter. A less common method during

periods of low fire danger is known as swamper burning or progressive burning. A fire is started in some spot clear of living trees and slash is piled on it to burn just as it is trimmed from newly felled trees. Or, after logging is complete, a somewhat similar method may be employed by starting a fire and gathering all nearby slash to burn progressively as it is handled.

Slash disposal by allowing fire to spread more or less completely over the ground has been practiced in several forms over many years. In the early days of American logging, it was common practice to fire slash areas indiscriminately. A major reason was low cost. Slashings were simply touched off and fire was allowed to run wild over the area. Slash was more or less destroyed, and so was timber remaining on the cutting area and often nearby as well. The most extensive application of broadcast burning as a means of slash disposal is in clearcutting of old-growth conifers. In most such areas, slash disposal by piling methods following clear-cutting is both impractical and prohibitive in cost. Also, the ground needs to be cleared to obtain satisfactory reproduction of desired species. Here, all merchantable material is removed, the balance of the stand felled, and the accumulation of fuels burned broadcast.

APPENDIX E

Fireline Equipment

All fire suppression techniques are directed toward removing one or more essential components of the fire triangle; i.e., heat, oxygen, or fuel. The most common method is fuel removal by creating a fireline void of fuels around the fire. A fireline is constructed by using power equipment, handtools, or fire retardant chemicals. Additional information is included in this appendix on equipment and handtools. This fireline is constructed down to mineral soil and will vary in width depending upon the type and condition of fuel, moisture conditions, and topography. The vegetation removed inside the fireline is equal in width to the height of the vegetation. Generally, a width of 18 inches is sufficient.

POWER EQUIPMENT

Power equipment is normally more efficient than line construction by hand and a variety of types are in use.

Plows. Originally agricultural equipment, various types and design of plows have been adapted and specialized for fire suppression to work. The line constructed is normally 12 to 18 inches in width, with the berm being rolled to the outside of the fireline. Plows are either mounted to the rear or pulled by trucks, crawler tractors, and tracked all-terrain vehicles (ATV's).

Bulldozers. These machines are used in construction work and applied to fire suppression normally without modification. The bulldozer is very effective in building roads and clearing lines. This crawler tractor clears a line 3 to 12 feet in width with the berm being thrown to the outside of the fireline. Bulldozers are usually operated in tandem for safety and operational reasons.

Rotary Trencher. The rotary trencher is a rotating flail that both constructs a fire trench or line and throws dirt. It can be a hand-held portable or pulled or mounted on a truck or bulldozer. The line width constructed varies between 12 and 24 inches. The dirt being flailed by the trencher can be placed on either side of the fireline, depending upon whether direct or indirect attack methods are to be used.

Pumper. These machines are pumping units mounted on trucks or tracked vehicles of various sizes with water or retardant tanks. These pumper units vary in size between 100- and 5,000- gallon capacity and have various types of pumps for water or retardant dispersal. The vehicles may also vary in size and type from two-wheel or four-wheel drive, through crew-cabs, to the ATV "Dragon Wagon" and various tracked vehicles. The pumper units are used in direct attack placing water or retardant on the flame front, inlaying a "wet line" for burnout or backfire, or in support of other firefighting operations.

Portable Equipment. Portable water pumps and chain saws are used in fireline construction in conjunction with heavy equipment and handtools. Portable pumps may be used in the same way as pumper units. Chain saws are used for rapid clearing operations in fireline construction.

HANDTOOLS

A great variety of handtools are used in fire control operations and are primarily for cutting and digging. The most commonly used for digging (line construction) are the Pulaski, shovel, Rich tool, McLeod, and mattock. Tools for cutting are the Pulaski, axe, brush hook, and saw. An associated piece of equipment used in conjunction with the handtools is the 3- to 5- gallon backpack water pump.

EQUIPMENT FOR BACKFIRING

Several types of torches are used in this practice. Some are hand held, other backpacked or mounted on vehicles; some utilize gasoline as fuel, others gasoline-Kerosene mixture, propane or kerosene. The most common is a solid fuel fireworks device which is an adaption of the familiar railroad or highway fusee.

AIRCRAFT

Aircraft are commonly used in the fire suppression program for various support and tactical assignments. Aircraft include fixed-wing support, fixed-wing tactical, and helicopters.

Fixed-Wing Support Aircraft. In logistical support of fire suppression operations, a wide variety of aircraft are in use. These aircraft are used to transport personnel, supplies, and equipment to the fire and return. Point-to-point (airport to airport) transportation is accomplished by aircraft varying in size from a two seater to the jumbo jet. The most common aircraft for this purpose are the various light twin engine aircraft as well as the heavier aircraft such as the DC-3, C-46, F-27, DC-6 and 7, Electra 727, 737, 707, C-130, and 720. For other than point-to-point delivery of supplies and equipment to the fire area, air cargo delivery systems are used. The cargo is rigged for air dropping and the supplies and the equipment are parachuted directly to the fire. The most common air cargo aircraft in current use for this purpose are the Beach 99, Twin Otter, Volpar, Caribou, DC-3, C-46, B-23, C-119J, and Skyvan. The carrying capacity of these aircraft varies between 3,000 and 19,000 pounds.

Fixed-Wing Tactical Aircraft. Fixed-wing aircraft are also utilized in a tactical way for suppression efforts directly on the fire. One use is for the direct placement of personnel by parachute into fire areas. These smokejumper aircraft vary in carrying capacity from 4 to 24 men.

The common aircraft types in current use are the Beach 99, Volpar, Skyvan, Twin Otter, DC-3, C-46 Grumman Goose, and Caribou. Other tactical aircraft carry water or chemicals to fires and deposit these agents directly on the fire. Some common types in use with carrying capacity are the B-25, 1,000 gallons; S-2, 800 gallons; B-26, 1,200 gallons; C-119J, 2,100 gallons; PB4Y2, 2,400 gallons; TBM, 650 gallons; PBY5A, 1,800 gallons; B-17, 2,000 gallons; DC-6 and 7, 3,000 gallons; P2V, 3,000 gallons; CL215, 1,5,000 gallons and C-130, 3,000 gallons. Other types of fixed-wing aircraft are also used in varying types and sizes to perform other tactical missions such as air attack, detection, and observation.

Helicopters. Helicopters offer a much higher potential for effective attack on fires from the air than fixed-wing aircraft. Helicopters in sizes ranging from 2 to 24 passengers are used in fire suppression work. They are utilized for hauling supplies and materials, hauling personnel, observation missions, initial attack with a trained crew, placing incendiaries for a burnout or backfiring operation, emergency medical evacuation, and dropping 150 to 1,000 gallons of water or retardant from a suspended water bucket or external tank. The most common types at the present time are both piston and jet turbine powered. They are Bell 47G series, Hiller 12 series, Bell 206A and B, 204B, 205A1, Hiller 1100, Boeing 105C, S-55T, S-61, Boeing Vertol, and Alouettes 2 and 3.

composition, season of the year, and amount of soil moisture. Another consideration in determining the need for seeding is the desirability of preventing the establishment of undesirable cover. Soil characteristics and climatic factors influence the species selection as well as the manner of seeding.

In certain areas of frail soils subject to heavy erosion by sporadic rains, or in critical watershed areas, the requirement for an immediate rehabilitation seeding project may be preeminent and call for seeding operations to begin even while suppression crews are mopping up the fire area.

Seed varieties used must be adapted to the site (climate, soil, topography, etc.). Vegetative monocultures are to be avoided. Areas with less than 8 inches annual rainfall should not be seeded unless augmented by contour furrowing or other water-collecting treatments.

Seed used in broadcasting must be able to sprout quickly and grow well without seedbed preparation or covering. Normally, broadcast seeding is confined to sites too rough for practical drilling and is usually accomplished more economically when done by aircraft.

PLANTING

Planting of trees and shrubs is usually too slow a process to provide the quick emergency cover desired to prevent soil erosion. However, it may be considered if evaluation indicates the trees and shrubs will give additional protection to the soil such as in the vicinity of gully control structures, channel stabilization works, etc. To replace species destroyed by the fire, the planting of trees and shrubs having wildlife, commercial and other values may be necessary if evaluation indicates satisfactory natural replacement will not occur within an acceptable period of time. (For reestablishing timber stands on commercial forest lands, refer to BLM Manual 5710.)

WATERSHED TILLAGE

When a fire rehabilitation objective that identifies the need for soil stabilization beyond that possible with management or seeding is established, then watershed tillage practices are considered. The primary function is to achieve the objective of preventing further loss-of-site productive capacity by keeping soil in place and aiding establishment of vegetation.

Furrowing and Trenching. Contour furrows/trenches are used mainly to prevent dry mantle floods and soil erosion that may result from high-intensity rainstorms by providing storage for overland flow. Factors considered in the use of furrows/trenches on fire rehabilitation projects are: The extent to which a gully stream has developed, soil characteristics and depth, steepness of slope, nature and value of property to be protected, character and frequency of rainstorms, and the extent to which the area may be stabilized by other treatments such as management or seeding to control runoff.

Ripping. The physical characteristics of the burn are carefully evaluated prior to the use of ripping practices in fire rehabilitation. Slopes should normally be less than 30 percent and the terrain generally free of sharp breaks which would prevent ripping on the contour. The burned area is carefully analyzed as to runoff potential by considering the soil (texture, depth, restrictive layer, etc.), slope and the intensity, amount of probability of high-intensity storms that may be expected during the first or second year. If examination indicates that a ripping project is needed, the project is designed to provide for: (1) ripping to sufficient depty (normally 15 inches or less) for transporting surface flow into the soil profile where it can be temporarily stored and (2) spacing of the rips to increase infiltration adequate to a rate necessary to handle the design storm intensity.

WATER CONTROL STRUCTURES

Water control structures such as detention dams, dikes and diversion dams are of assistance in fire rehabilitation projects to curb channel erosion and headcutting or for protection from flood and sediment damages. Adequate consideration is also given to land treatment and management practices upstream from the structures.

Detention Dams. When potential flood and sediment damage is high, detention dams are used independently of other practices or in conjunction with seeding or tillage practices for reducing damage potential. However, such structures are used only where the anticipated benefits offset installation costs. Detention dams often provide the most immediate and positive means for retarding floods and reducing sediment yield following a fire that has destroyed the protective ground cover on a watershed.

Dikes and Diversion Dams. Dikes and diversion dams are not as effective in controlling floods and reducing sedimentation damages as are detention dams. However, they are used where the topography is suitable and where no potential dams and land treatment practices to curb channel erosion and headcutting are planned.

SALVAGE LOGGING

Commercial logging of timber damaged beyond recovery by fire is accomplished whenever possible. Although this practice may not be considered as rehabilitation from the standpoint of stabilizing a watershed or restoring wildlife habitat, it does allow for harvesting of timber that would otherwise be wasted and reduces human hazards resulting from dead snags. Further, it facilitates subsequent seeding or other type of rehabilitation practices.

Fire Rehabilitation Plan Outline

Fire Number

I. Background: (Current Situation)

A. Fire Identification

1. Location
2. Soils
3. Topography
4. Climate
5. Vegetation prior to burn
6. Intensity of burn
7. Hydrology
8. Soil surface factor prior to burn

B. Resource Uses

II. Evaluation and Analysis:

A. Onsite physical factors (damages to watershed); erosion hazard - wind, water

B. Offsite nonphysical factors, water quality, sedimentation

C. Wildlife or other factors

III. Rehabilitation Needs and Objectives:

A. Alternatives

B. Recommendations

1. Treatment
2. Management

C. Justification

IV. Environmental Considerations:

A. Discuss positive or negative impacts of alternatives proposed.

B. Management Framework Plan (MFP) status (was MFP used?)

V. Annual Work Plan (AWP) Summary:

A. Description of units

B. Cost per unit

C. Man-months

D. Other job requirements--pounds of seeds by species

E. Cooperative programs

F. Scheduling sequence

VI. Map Exhibit:

A. Perimeter of fire should be shown in black.

B. Boundaries of treatment areas by symbol.

C. Show all existing jobs in addition to proposed.

APPENDIX G

Prescribed Burning--Guides and Plan

Prescribed burning is the skillful application of fire to fuels in a specific area to accomplish certain management objectives. It requires professional knowledge and application of fire behavior and effects principles as well as knowledge of the specific ecosystem alterations to be made in order to achieve the objectives--the latter, usually an optimum compromise of the objectives of several resource disciplines. Any prescribed fire may have more than one objective (Martin and Dell, 1978). A successful prescribed fire standard is one that is implemented safely, burns under control, meets the prescription, and attains the land measure and resource management objectives for the designated area (Fisher 1978).

All prescribed burning projects require specific approval before activation. They are prepared at field level for approval administratively within BLM and, where applicable, by the local state clearinghouse. Included in the plan is a smoke management plan (see appendix H) which must also be approved by the state clearinghouse and local air quality offices.

Preparing the plan requires on-the-ground examinations and problem assessments. Topographic maps or aerial photos are necessary in order to competently lay out burning sequences, etc. Detailed outlines supplemented by lists of possible data or requirements for each topic are very desirable tools for planning and for a checklist to avoid oversights.

Outline of minimum plan requirements follows:

Prescribed Fire Use Plan Outline

I. Treatment Area and Objectives

A. Purpose of the Plan

B. Treatment Area

C. Land & Resource Management Objectives

D. Treatment Constraints

E. Treatment Objectives

F. Treatment Alternatives

II. Fire Prescription

A. Treatment Specifications

B. Treatment Strategy

C. Preburn Monitoring

D. Evaluation

III. Burning Plan

A. Preparation For Burning

B. Preburn Monitoring

C. Ignition

D. Holding

E. Mopup

F. Evaluation

G. Cost Summary

IV. SMOKE MANAGEMENT PLAN

(See separate plan in Appendix H)

V. Environmental Analysis

VI. Report

A. Accomplishments

B. Fire Behavior

C. Environmental Conditions

D. Cost

E. Observations and Recommendations

References

Fisher, W.C. 1978, Planning and Evaluating Prescribed Fires- A Standard Procedure. U.S. Forest Service, Intermountain Forest and Range Experiment Station; General Technical Report INT-43, Ogden, Utah, 19 pp.

Martin, R.E. and J.D. Dell, 1978, Planning for Prescribed Burning in the Inland Northwest. U.S. Forest Service, Pacific Northwest Forest and Range Experiment Station; General Technical Report PNW 76, Portland, Oregon, 67 pp.

APPENDIX H

Model Smoke Management Plan for Prescribed Burning of Forest or Range Residue

Land Managers have moderate flexibility in determining the when, where, and how much of their burning and, with proper fuel preparation, they can usually await conditions favorable for both burning and smoke dispersion. Since burning operations require elaborate planning and at the time of execution involve considerable deployment of equipment and personnel, the burn must usually be scheduled in advance on the basis of predicted conditions described in the appropriate fire-weather forecasts.

In the event that all requirements for a prescribed burn are met except that timing and ignition methods are not as planned, the resulting fire may be considered a prescribed burn as long as it meets the prescription requirements. But as a prescribed fire, it must also meet prescribed fire-smoke management requirements as set forth in this plan, specifically with respect to amount of smoke produced each day and how and where it may be expected to disperse.

Objective

The objective of this plan is to minimize smoke resulting from burning of forest or range residues and to prevent it from being carried to or accumulating in areas sensitive to smoke. Smoke Sensitive Areas (SSA) are defined as heavy population or high-use areas that are susceptible to excessive accumulation of atmospheric emissions because of climatic and topographic restraints on ventilation, such as in natural basins. SSA boundaries may be defined in terms of the confining terrain, distance from heavy population, and ceiling 2,000 feet above mean terrain level. SSA's are agreed upon jointly by State forestry and State air quality control agencies and participating resource management agencies.

Administration

Each field manager issuing permission to burn under this plan will manage the prescribed burning on public land in connection with the management of other aspects of the environment in order to maintain a satisfactory atmospheric environment. Accomplishment will entail a consideration of weather forecasts, acreages involved, amounts of material to be burned, evaluation of potential smoke column vent height, direction and speed of smoke drift, residual smoke, mixing characteristics of the atmosphere, and distance from any SSA for each burning operation.

This plan provides a decision base for air quality considerations applicable to most prescribed burning situations. Exceptions may occur when, because of unusual conditions of wind and stability, dispersion within the suggested distances will not be adequate. Coordination beyond the plan will also be necessary to assure that plumes from separate fires within or outside an administrative area do not join to produce an unacceptable smoke condition.

The project leader will evaluate downwind conditions prior to starting a burn. When he determines that visibility in a downwind SSA is already less than 11 miles or would likely become so with additional burning, or upon notice that air in the State, or adjacent State, or any portion thereof, is, or would likely become excessively affected by smoke, the administrator will likely require burning to be cancelled or terminated. Upon termination, any burning already underway will be completed as rapidly as possible and mopped up as soon as practical and no additional burning will be attempted until favorable conditions again occur.

When residue to be burned is within 100 miles of a downwind SSA, the specific provisions of the Residue Burning Restrictions for Smoke Management relating to quotas and smoke drift apply, as well as the Procedures for Minimizing Smoke Production and Impact. If the residue to be burned is beyond the 100-mile limit, only the more general Procedures for Minimizing Smoke Production and Impact apply.

APPENDIX I

Soil Stability Class

SOIL WETNESS

Soil wetness is very important because water tends to "float" the soil mantle just as a person "floats" in a swimming pool. The soil mantle slides out of a wet area if a road cut removes the support just as water runs out of a swimming pool if a side is removed. Soil wetness is apparent in:

- Seeps, springs, and other areas where water is on top of the soil surface;
- Presence of hydrophytes--the hydrophytes must be defined locally;
- Meadows;
- Black soils--these types of soils must be defined locally as having high water tables, as many black soils are well drained;
- Soils that are gleyed and/or mottled;
- Small ponds of water located adjacent to an old slump escarpment (sag ponds).

AREAS WHERE CONSOLIDATED BEDROCK IS MORE THAN TEN FEET BELOW THE SOIL SURFACE

Consolidated, continuous bedrock close to the surface provides a sound foundation to support the soil mantle above an area of disturbance. Fractured weather or deep bedrock does not provide support once the area is disturbed. Consequently, the soil mantle slides down the hillside. Cohesionless types of soil pose the highest hazard for landsliding on areas described in this category. Such areas include:

- Fault zones - consolidated bedrock is ground and fractured by the faulting action;
- Pockets of colluvium which have accumulated from previous erosion processes;
- Any type of rock that is composed of hard fragments cemented by a finer grained matrix and the matrix is weathering into clay minerals (examples would be conglomerates, agglomerates, tuffs, breccias where the matrix has undergone considerable weathering).

- Areas where the rock has weathered to great depths into soft materials which can be dug with a shovel.

AREAS WHERE THE SOIL MANTLE IS PRESENTLY SLIDING

(a) Tension cracks--this is where the soil mantle has cracked open as soil moves downhill away from soil that has stayed in place;

(b) Hummocky hillsides--usually occur in plastic soils which are slowly moving downhill;

(c) "Jackstrawed" or "crazy" trees--trees tilted at different angles while having a straight trunk denote very recent soil movement;

(d) Curved tree butts--the soil mantle has slid slowly during the lifetime of the tree;

(e) Depressions resulting from the withdrawal of material downslope.

The headwalls of drainages are often very steep due to the natural erosion processes. These areas are very prone to mass soil wasting if they are disturbed. The headwall is that portion of a streamdraw that has a very sharp increase in slope gradient from the toe of the mountain to the ridge tops or saddle.

APPENDIX J

Soil Classifications

Soil classification is the systematic arrangement of soils into classes in one or more categories or levels of classification for a specific objective. Broad groupings are made on the basis of general characteristics and subdivisions on the basis of more detailed differences in specific properties.

Order is the category at the highest level of generalization in the soil classification system. The properties selected to distinguish the orders are reflections of the degree of horizon (soil layer) development and the kinds of horizons present. The 10 orders are:

Alfisols

Soils that contain a good supply of bases and subsoils high in clay, with gray to brown surface layers. These soils from primarily under forest or savannah vegetation with climates of slight to pronounced seasonal moisture deficit.

Aridisols (L. aridus, dry)

Soils characteristic of dry places with natural horizons low in organic matter and a definite moisture deficiency. They have light-colored surface soils with distinct structure. These soils have developed in arid regions under sparse shrub vegetation.

Entisols (recent soils)

Soils that have no distinguishable natural horizons. They may be found in practically all climate regions on recent geomorphic surfaces, either on steep slopes that are undergoing active erosion or on fans and flood plains where the recently eroded materials are deposited.

Histosols (Gk. histos, tissue)

Soil formed from organic soil materials.

Inceptisols (L. inceptum, beginning)

Soils that are usually moist with natural horizons, thought to form rather quickly from altered parent materials, but not by accumulation. Generally, soil development is not evident from the soil-forming processes. These soils are found under deciduous forest in temperate humid regions and also under wet or poorly drained conditions.

Mollisols (L. mollis, soft)

Soft characterized by nearly black, organic-rich surface horizons with high natural fertility. These soils have an accumulation of relatively large amounts of organic matter and have good structural properties. These soils are formed in a cool sub-humid to a warm, semiarid climate under varying vegetative types including deciduous forest, grasslands, halopytic plants, etc.

Oxisols (F. oxide, oxide)

Soils of tropical and subtropical regions characterized by extreme weathering which results in an accumulation of inactive clays, oxides or iron and aluminum and quartz. These soils are formed under humid, forested conditions.

Spodosols (Gk. spodos, wood ash)

Soils with subsurface horizons containing an accumulation of organic matter and compounds of aluminum and iron. These soils are formed in acid coarse-textured materials in humid and cool or temperate climates under coniferous or mixed coniferous and deciduous forests.

Utisols (L. ultimus, last)

Soils of humid tropical areas characterized by subsurface horizons of clay accumulation or a cemented layer (fragipan). They are low in natural fertility due to a loss of bases through weathering and removal by leaching. These soils formed under wet-dry seasons and tropical forest vegetation.

Vertisols (L. verto, turn)

Clayey soils with high shrink-swell potential which have wide, deep cracks when dry. These soils have developed under widely varying climatic conditions, but usually with altering wet and dry seasons.

A comparison of the new soil classification systems with approximate equivalents of the old system follows:

	New (Order)	Old (Great Soil Groups)
1.	Alfisols	Gray Brown Podzolic, Gray Wooded Soil, Non-Calcic Brown soils, Degraded Chernozem, and associated Planosols and some Half-Bog soils--Zonal order.
2.	Aridisols	Desert, Reddish Desert, Sierozem, Solonchak, some Brown and Reddish-Brown soils, and associated Solonetz--Zonal and Intrazonal orders.
3.	Entisols	Lithosols, Regosols, and Alluvial soils with some Low-Humic Gley soils--Azonal and Intrazonal orders.
4.	Histosols	Bog soils--Interzonal order
5.	Inceptisols	Ando, Sol Brun Acide, some Brown Forest, Low-Humic Gley, and Humic Gley soils--Zonal and Intrazonal orders.
6.	Mollisols	Chestnut, Chernozem, Brunizem, Prairie, Renzina, some Brown, Brown Forest, and associated Solonetz and Humic Gley soils--Zonal and Intrazonal orders.
7.	Oxisols	Laterite soils, Latosols--Zonal order
8.	Spodosols	Podzols, Brown Podzolic soils, and Ground-water Podzols--Zonal and Intrazonal orders.
9.	Ultisols	Red Yellow Podzolic soils, Reddish-Brown Lateritic soils, and associated Planosols and Half-Bog soils--Zonal and Intrazonal orders.
10.	Vertisols	Grumusols (dark clay soils)--Intrazonal order

APPENDIX K

Description of Characteristic Soil Series in Major Biomes

Tables K-1 through K-10 (at end of this appendix) have been prepared for each biome or biological community (except the subtropic community) to assist those wishing to prepare more detailed analysis on specific areas. Some characteristics, uses, and limitations are given for each of the listed soil series. Specific items for each soil such as the unified classification of the subsoils for engineering uses and hydrologic groups are given, as well as general information. Thus, the information may be used by engineers, hydrologists, and soil scientists, as well as the general public, to gain some knowledge of the soils. The listed soil series are not inclusive. They occur extensively in the region under which they are identified, but they must be viewed as examples. A detailed, onsite soil survey must be made before the total soil resource is known. More detailed information of the soils 7 characteristics and limitations may be obtained from the soil survey reports listed in the selected references.

Definitions of Table Headings

SOIL NAME

Each soil series in the United States is given a name. The name identifies a specific soil just as names identify people. Soil names are correlated so that any one name applies only to a specific soil, regardless of occurrence.

UNIFIED CLASSIFICATION (UC)

This is one of the two systems that classify soil material for engineering uses.

The unified soil classification systems identify soils according to their textural and plastic qualities, and their grouping with respect to their performance as engineering construction materials. Soil materials are divided into 15 classes; 8 classes are for coarse-grained material, 6 classes are for fine-grained material, and 1 class is for highly organic material. Soils that have characteristics of two classes are designated by symbols for both classes; for example, CL or ML. Each class is identified by a letter symbol. GP identifies poorly graded level and mixtures of gravel and sand with little or no fines. Soils in class SM are silty sands and mixtures of sand and silt. Soils in class ML are inorganic silts of low-liquid limit which are mixed with sand and clay. Soils that are predominantly silts and clays, which have a low-liquid limit, are in class CL. The symbol CH identifies inorganic clays that have a high-liquid limit and plasticity.

The first letter of the class symbol indicates the grain size, for example, G stands for gravel, S for sand, M for silt, C for clay, and O for organic. The codifying terms indicated by the second letters are: P for poorly graded, W for well graded, M for silty, and C for clayey. The symbol L stands for low-liquid limit and H for high-liquid limit.

AVAILABLE WATER CAPACITY (AWC)

Available water capacity refers to the total quantity of water, which is stored in the effective root zone of the upper 60 inches of the soil profile at field capacity, available for plant growth. It is largely dependent upon the effective depth, texture, structure, porosity, organic matter content, and coarse fragment content. In general, profiles that contain 50 percent coarse fragments by volume will only have one-half the moisture-holding capacity of a comparable soil that is free of coarse fragments.

HYDROLOGIC GROUP (HG)

Soils are placed in hydrologic groups according to their potential to yield runoff. This information is used in watershed planning. Various hydrologic groups range from those that shed almost no precipitation (A) to those that shed nearly all the precipitation. (D).

A - Very deep, coarse- and moderately coarse-textured soils that transmit water through their profiles and substratum at a high rate. These soils have lowest runoff potential.

B - Medium- to fine-textured, moderately deep to very deep soils having a moderate rate of water transmission through the profile.

C - Fine-textured, deep and very deep soils that have a slow rate of water transmissions through the subsoil.

D - Fine-textured, deep soils, and impervious material exposed or covered by a thin mantle of soil. These soils have the highest runoff potential.

RELIEF

Relief is expressed as a range in the slope percentage that each soil may have.

APPENDIX L

Fire Planning System

This appendix provides a description of the activities performed in the development of a Normal Fire Year Plan. This plan represents an activity plan (fire management) and is a part of the total BLM planning system.

A. THE BLM PLANNING SYSTEM

Each of the BLM districts is subdivided into areas called "planning units." This division may be based on topographic, geographic, resource or land ownership criteria. For each planning unit two documents are prepared: a Unit Resource Analysis (URA) and a Management Framework Plan (MFP).

1. Unit Resource Analysis (URA)

The URA provides an inventory of the resources and an evaluation and plan for utilizing the resources in the Planning Unit on a resource-by-resource basis (without consideration of other potential resource uses). The resource uses considered in this evaluation are grazing, forestry, recreation, watershed management, wildlife habitat, mineral resource development and land sales. From these independent evaluations conflicts in potential land use are identified and defined. The fire management input to the step 2 URA consists of a description of the fuels available, the value at risk and the fire behavior. these characteristics are combined to provide an evaluation of the fire problem in the planning unit.

2. Management Framework Plan (MFP)

The MFP uses the information provided in the URA as its input and develops a plan which the District management believes makes the best use of the land's resources. This plan resolves the conflicts defined in the URA and provides direction for development of each resource. The fire management input to the MFP step 1 consists of a plan for fire management within the district based on the fire problem defined in the URA.

B. NORMAL FIRE YEAR PLANNING ACTIVITIES

The major effort in development of the Normal Fire Year Plan is performed at the district with review and compilation into the State plan at the State. Final review is performed at the Boise Interagency Fire Center (BIFC) and approved by the BLM Director, Washington Office. The plan preparation effort performed at the District can be divided into the following 10 activities:

1. Guidance materials review
2. Normal Fire Year determination
3. Problem identification
4. Land ownership classification
5. Requirements analysis
6. Preliminary plan preparation
7. Coordination
8. Preliminary plan modification
9. Budget products generation
10. Submission of district plan to State

The State activities are:

1. District plans review and coordination
2. District plans analysis and modifications
3. State plan preparation
4. State plan submission to BLM

The Washington Office activities are:

1. Guidance material preparation
2. State plans review
3. State plans analysis and modification
4. State plan approval

The Boise Interagency Fire Center supports the Washington Office in performance of items 1 and 2.

C. DISTRICT NORMAL FIRE YEAR PLAN DEVELOPMENT ACTIVITIES

The primary effort in development of the Normal Fire Year Plan is at the BLM district, for it is in the district that the detailed knowledge of the area exists.

1. Normal Fire Year Determination

After review and understanding of the guidance material provided to the district by BLM, a major step in preparation is to identify the Normal Fire Year. The Normal Fire Year is defined as the third worst fire year of the previous 10 years.

The problem is to identify that year which most nearly resembles a calculated Normal Fire Year. The calculated Normal Fire Year is formed from the third worst occurrence in each of five categories of fire size, each of which are normalized using the third worst fire occurrence total for the years under consideration. The techniques combine a pure mathematical manipulation of the data with subjective analytical judgment in choosing candidate Normal Fire Years (those years which best fit the number of fires per size class distribution). From among the candidate years, that year is picked which best matches the 10-year average fire distribution over the fire season. This later step is a graphical

matching procedure and is presently highly subjective. The Normal Fire Year selected as a result of this analysis defines the Normal Weather Year used in the problem identification analysis.

2. Problem Identification

The fire problem has three components: fire behavior, fire occurrence and values at risk. These fire problem components are evaluated independently and then combined to provide an evaluation of the fire problem in the district. The values at risk and fire behavior are combined to determine a Fire Control Condition (FCC). The FCC is then correlated with the fire occurrence to determine the scope, extent and nature of the fire problem in the area.

(a) Values at Risk

The determination of the values at risk provides a quantitative measure which can be used in determining the type of fire suppression action an area requires. There are seven resources considered in determining the values at risk. These are: soil, water, grazing, forestry, wildlife, recreation, and air. The diverse nature of these resources precludes the use of a single scale of values (such as dollars) in evaluating the individual resource values. Therefore, each resource is evaluated on a scale of 0 to 100 based on specific predefined criteria. For example, soil where little to slight erosion can be expected with vegetative disturbance or reduction and the soil productivity is generally low (400-600 lb/acre/yr) would be assigned a point value in the range of 21 to 40. The determination of values at risk is done for areas of at least 100,000 acres which are usually defined based on topographic or range features. The evaluations are made by District Resource Staff experts who use their familiarity with the area and interpret the Normal Weather Year effects to provide the point value determinations. The point values determined for each resource are plotted on individual resource overlays and areas of like values are outlined. A single point value is then assigned as representative of each area. The seven resulting overlays are then graphically added and a summation overlay created. These totals are assigned to a Relative Value Class from 1 to 5 (5 being the highest value class) and the overlay redrawn to these Relative Value class boundaries. In all cases the subjective evaluations are justified using evaluation forms and narratives where necessary. Note that it is possible that the occurrence of fire could increase the land value. These cases would result in a negative value at risk and are labeled 1B on the value-at-risk overlay.

(b) Fire Behavior

Fire behavior is determined from a combination of the fuel type, slope of the terrain and meteorological characteristics of an area. The fuel type is determined using the Unit Resource Analysis vegetative typing, taking into consideration the weather characteristics during the month with the highest frequency of fire occurrence in the normal weather year and its effects on the vegetation growth characteristics. The resultant estimate of fuel size distribution and density is used to assign a Fahnstock spread rating. The Fahnstock spread rating provides a numeric value of from 0 to 100 which defines the potential of the vegetative growth to sustain and spread fire. The higher the Fahnstock rating the higher is this potentital. This rating is modified based on the terrain slope and normal weather year meteorology (wind and fuel moisture) in the peak fire month.

Based on the spread rating, slope and wind, a fire area perimeter increase value in the chains/hour is determined. The perimeter increase value is converted into a fire behavior rating from 1 to 5 with 5 being the highest rate perimeter increase. The analysis are performed using overlay techniques and the final results displayed on an overlay which combines areas of equal fire behavior rating. Resultant areas below 50,000 acres in area are combined into adjoining areas.

(c) Fire Control Condition (FCC)

The values-at-risk rating and the fire behavior rating are summed to determine the Fire Control Condition (FCC). Thus, an area with a values-at-risk rating of 4 and a fire behavior rating of 3 would have an FCC of 7. This analysis is performed by graphically adding the values-at-risk overlay to the fire-behavior overlay and creating an FCC overlay.

(d) Fire Occurrence

Fire occurrence information is obtained from the Individual Fire Report Form submitted on every fire reported on Department of Interior lands. Overlays are generated from these reports for the first and last 5 years in the previous 10 years. For each fire occurrence in these periods the location, month, and ignition source are plotted. These fire occurrence overlays are matched to the FCC overlay, the percent of the total fire occurrence for each FCC area is determined and the overlay annotated. The projected ignitions values in each FCC area is determined by multiplying the District Normal Fire Year load by these percentages. The number of anticipated ignitions is plotted on the FCC overlay below the fire occurrence percentage.

(e) Action Modification Analysis

There are certain situations which present critical fire control requirements regardless of the resources value, fire control condition or fire occurrence situation. These are areas which present risk to human life, have a high value override or are particularly sensitive for other reasons. This would include such areas as areas of residence, urban encroachment, campgrounds, picnic facilities, commercial facilities, scenic views, and critical wildlife habitats. These areas are indicated on the fire problem overlay in red. The intent is to create a safety zone around these areas in order to allow for fire control before a fire could burn into these areas.

Other conditions which are noted on the fire problem overlay are:

(1) Areas where fire is to be used as a management tool, and

(2) Areas which have equipment use limitations.

Where fire is to be used as a management tool, a conceptual burn prescription is prepared with an environmental analysis for each designated area. Equipment limitations are also identified and explained on the fire problem overlay.

3. Land Ownership Classification

The purpose of this analysis is to classify the land areas in accordance with the degree of BLM ownership. Land areas with a low degree of BLM ownership are candidates for performance of the fire protection function through cooperative arrangements with other government agencies or through contractual arrangements. Of course, there could be local considerations that would preclude non-BLM fire control. For example, in the eastern half of Montana, BLM is the only organized source for fire protection. Therefore, BLM has taken on fire control responsibility in this area even though the BLM-owned land is generally less than 50 percent of the land area.

The analysis is performed using BLM land ownership maps. For each grouping of four townships (approx. 100,000 acres) an estimate of the percentage of land owned by BLM is made. Based on this estimate the area is placed into one of these categories:

(a) Over 50 percent owned by BLM is designated as "best blocked,"

(b) Between 25 percent and 50 percent owned by BLM is

designated as "blocked," and

(c) Below 25 percent owned by BLM is designated as "scattered."

Land ownership overlays are created which display these categories of ownership for use later in the analysis.

4. Requirements Analysis Activity

These are six fire management functions which need to be structured to create a fire management plan to meet the needs identified by the fire problem. These functions are prevention, detection, initial attack, fire support, training, and communications. Each of these functions can be performed in different ways, at different locations, and by different groups. In addition, activity in one function could impact the requirements for another function (for example, prevention activity could reduce the requirements for initial attack). The purpose of the requirements analysis activity is to identify that system configuration which best meets the fire problem and the BLM goals and objectives in the MFP.

(a) Prevention

Three aspects to the fire problem are fuels, weather, and human behavior. Controlling or changing any of these will help the control of the fire problem. Work on weather modifications which is directed toward reducing the number of lightning-caused fires and providing moisture to otherwise high-fire-risk areas is presently in the research stage and, therefore, not operational.

(b) Detection

One of the BLM planning objectives is to confine 90 percent of all wildfires to less than 10 acres in size. To accomplish this objective requires the detection of these fires while they are small enough to be reached and controlled before they exceed this 10-acre threshold. The techniques used for wildfire detection are:

a) aircraft patrols
b) fixed lookout stations
c) ground patrols
d) public reports (including pilot reports)
e) Automatic Lightning Detection System (ALDS)

(c) Initial Attack

Initial attack is the first attempt at suppressing a wildfire. The initial attack process may use one type of fire control force or may combine the capabilities of several types of forces. A fire is said to have escaped initial attack if it has not been controlled by 10 a.m. local time on the day after the fire was reported. The significance of the 10 a.m. time is that it is usually very difficult to control a wildfire during the hot times of the day, because at these times the fuels are driest and convective air currents strongest. Thus, a fire not controlled by 10 a.m. probably will continue out of control until 4 p.m. before any headway could be made toward its control. (Alaska represents an exception due to the long summer period of daylight.)

Initial attack is the basis for planning the fire control force strength required at the State and district. The BLM strategy is to take advantage of a small local fire suppression force, the variable nature of the fire problem, the ability to quickly move fire control forces among the States and from BIFC, the ability to activate BLM non-fire-control personnel, the ability to use other agency fire control forces, and the ability to quickly hire and train local forces to provide the resources to control fires which have escaped initial attack. This is the BLM "mobility" concept of fire control.

(d) Fire Support

Fire support is the process of controlling wildfires which have escaped initial attack. Each district maintains a small force above its initial attack requirements for fire support. Should additional forces be required a fire order is submitted to the State. The State office will review the fire activity in other districts and if possible fill requirements for forces using fire control personnel within the State, from other districts, or other agencies by activating non-fire-control BLM personnel or by bringing in emergency firefighters (EFF) from prearranged sources. If the State cannot meet the needs of the district a Fire Order will be submitted to BIFC. BIFC has its own resources which it can assign to a fire or it can call upon resources from other States and/or other agencies through its own prearranged contractual sources.

Once a fire has escaped initial attack, a formal line organization is created and given responsibility for controlling the fire. The head of this organization is the fire boss and depending on the size and complexity of the fire he will be assisted by specialists.

(e) Training

A very comprehensive report "Fire Training A Report" (undated) with its appendices provides a detailed review and plan for training within BLM. This training report has been accepted by BLM management and will form the basis of the direction training will take over the next decade.

The lead role for training within the BLM fire management organization will be BIFC, who will develop courses structured for teaching by correspondence, programmed instruction, teaching machines, etc.

Programs will be balanced between agencies and universities to take advantage of every training opportunity.

(f) Communications

As in any tactical operation, communications is the key to successful fire control. First the fire detection report must be communicated to BLM and reach the dispatcher responsible for the fire area. The dispatcher must then notify the forces he wants assigned as to the fire location, size, etc. The field forces must communicate with each other, with the dispatcher, and with any aircraft or helicopters involved in the fire control activity. If added resources are needed, this must be communicated to the State office and so on.

Because of the importance of communications there are one or two communications specialists assigned to each State office in the Technical Service Division. In Alaska there is a separate division of communications with six communications specialists. In addition, Alaska and some other States have communications specialists at the district offices. To further highlight the importance of communications, BIFC now sends a communications specialist to all fires requesting communication equipment. This specialist discusses the communications needs with the fire boss and then sets up a communication system tailored to the particular situation.

5. Force Selection

In any district there are four choices for accomplishing the fire suppression program:

a) BLM force account
b) Other government agency (cooperator)
c) Contract
d) Respond when called (a low-level force account approach).

6. District Plan Preparation

Using the Normal Fire Year to define the fire occurrence probability in space and time over the district; the value-at-risk analysis to define the economic and political importance of providing protection to various areas within the district; the fire control conditions to define the fuel and control situation; the land ownership classification analysis to determine the responsibility for protection by land ownership in the various areas of the district, a fire problem identification analysis is made. Using this problem analysis and a knowledge of the types of resources and fire management techniques available to the district, a preliminary district plan is prepared. This plan identifies the most cost-effective combination of manpower material and equipment (including the placement of the resource) required to meet the objectives of the MFP. Where fire management in any area of the district is to be performed by cooperators or contractors the source of this assistance is identified.

Appendix M

FIRE MANAGEMENT PROGRAM AND ALTERNATIVES

Comparison of Activities and Practices

Descriptive Element	Proposed Fire Management Program	Alternatives to proposed action: Total Fire Control Program	Alternatives to proposed action: Limited Fire Control Program
Objective	Reconnaissance of all wildfires.	Reconnaissance of all wild fires.	No reconnaissance or suppression action, some prevention practices on high resource value areas.
	Suppression action within framework of management objectives and plans with suppression efforts conditioned by potential damage, least expenditure	Suppression action directed toward minimum burn acreage with secondary consideration of resources values.	

Descriptive Element	Proposed Fire Management Program	Alternatives to proposed action: Total Fire Control Program	Alternatives to proposed action: Limited Fire Control Program
	of public funds for effective suppression, suppression methods least damaging to resources and environment, integration of suppression with others, and highest priority to the disaster fire.		
	Full use of prescribed fire to achieve land and resource management goals for the protection and enhancement of human and natural resource values.		
PREVENTION AND PRESUPPRESSION			
Planning	Based on management framework plans with public participation, decision on best mix of land and resource uses,	Based on fire control with minimum area of burn the primary consideration.	Based on prevention practices in high resource value areas

Descriptive Element	Proposed Fire Management Program	Alternatives to proposed action: Total Fire Control Program	Alternatives to proposed action: Limited Fire Control Program
	with fire management activities, and practices needed to support identified multiple uses.		and no presuppression or suppression practices.
Information & Education	Public exposure of (a) the prevention and the destructive nature of wildfires, (b) the positive aspects of prescribed fire, and (c) the possible consequences of fuel buildup and increased risk of wildfire.	Practice centered on the prevention of wildfires.	Practices centered on the prevention of wildfires in high resource value areas.
HAZARD REDUCTION	Practices include removal of fuels and limiting spread following ignition.	Same as proposed action except practices are designed toward minimum burn acreage and a reduction in the total number of fires.	Same as other alternative except practice is limited to high resource value areas.
	Based on risk of wildfire, resource		

Descriptive Element	Proposed Fire Management Program	Alternatives to proposed action: Total Fire Control Program	Alternatives to proposed action: Limited Fire Control Program
	value, potential damage, least expenditure of funds, method least damaging to resources and environment.		
	Goal is the prevention of large or uncontrollable wildfires rather than simply a reduction in the total number of fires.		
Detection	Lookouts, patrols, cooperators, and the public reporting telltale smoke.	Same as proposed program.	No organized detection.
Research and Training	Professional field concerned with (1) the physical, biological, and social sciences, (2) the applied field of meteorology, engineeering administration, and natural resource	Same as proposed action except for prescribed fire.	Same as proposed action except for presuppression, supresion, and suppression activities.

Descriptive Element	Proposed Fire Management Program	Alternatives to proposed action: Total Fire Control Program	Alternatives to proposed action: Limited Fire Control Program
	management, (3) the on-the-ground application of skills, and (4) the interdisciplinary approach to problem solution.		
	Research and training are designed to control destructive wildfires and to use prescribed fire as a tool.		
SUPPRESSION			
Initial Attack	Places maximum emphasis on speed and strength of attack.	Same as proposal.	None
Continued Suppression	Suppression action guided by objectives, i.e., consideration of resource values, environment, and potential damage and values lost; least expenditure of funds for effective suppression	Suppression action designed to control wildfire and achieve minimum burn acreage.	None.

Descriptive Element	Proposed Fire Management Program	Alternatives to proposed action: Total Fire Control Program	Alternatives to proposed action: Limited Fire Control Program
	to bring the wildfire under control and stop its spread.		
Mop-up	The last stage of suppression activity designed to cool down burning material near the fire edge and later extinguish remaining spots until the fire is out.	Same as proposal.	None.
POSTSUPPRESSION			
Evaluation	Identifying damage caused by wildfire	Same as proposal.	None.

Descriptive Element	Proposed Fire Management Program	Alternatives to proposed action: Total Fire Control Program	Alternatives to proposed action: Limited Fire Control Program
Planning & Implementation	and suppression practices, weighing and deciding the consequences of rehabilitation or no rehabilitation, establishing practices for rehabilitation to fulfill conservation objectives, and requesting and budgeting funds for needed rehabilitation. Rehabilitation of most damages from suppresion practices are performed immediately after mop-up.		
PRESCRIBED FIRE	Controlled application of fire to wildland fuels to achieve preplanned objectives. The scientific and extensive use of fire for disease control, rough reduction, fuel reduction, and	Prescribed burning for hazard reduction limited use on site preparation.	Prescribed fire in high resource value areas for hazard reduction.

Descriptive Element	Proposed Fire Management Program	Alternatives to proposed action: Total Fire Control Program	Alternatives to proposed action: Limited Fire Control Program
	habitat improvement. Also includes the preplanned natural role of fire in special areas, such as wilderness areas.		

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